BLANCHARD RIVER WATERSHED STUDY

DRAFT INTERIM FEASIBILITY STUDY

APPENDIX D

ENGINEERING & DESIGN

December 2014

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1.0 INTRODUCTION

The Engineering & Design Appendix presents the supporting technical information used in evaluating the existing flooding conditions, the plan formulation, developing an array of possible structural measures and developing the Tentatively Selected Plan features for the Blanchard River Watershed Study in the City of Findlay, Hancock County, Ohio. Discussion of the proposed non-structural measures for the Tentatively Selected Plan are presented elsewhere in this report. This information supports the economic and design analyses of the Tentatively Selected Plan and its baseline cost estimate. It should be noted that the Village of Ottawa, Putnam, Ohio was previously part of this study. In 2014, the Village of Ottawa decided to drop out of the study and pursue flood risk management independently. Therefore the Tentatively Selected Plan does not include the Village of Ottawa. However, flood risk management measures previously developed for the Village of Ottawa are included in this appendix for historical documentation.

2.0 PROJECT PURPOSE

The purpose of the Blanchard River Watershed Study was to assess the Federal interest in participating in potential flood risk management plans that in the City of Findlay; formulate and evaluate potential plans; and identify plans which maximize net economic benefits.

3.0 HYDROLOGY AND HYDRAULICS

The Blanchard River Watershed is located in portions of Allen, Hancock, Hardin, Putnam, Seneca and Wyandot Counties in northwest Ohio (see Figure 1). The watershed is delineated by the U. S. Geological Survey as 8- digit hydrologic unit number 04100008. It rises in central Hardin County, approximately 5 mi (8 km) northwest of Kenton. It flows generally north for its first 25 mi (40 km) into eastern Hancock County, where it turns sharply to the west. It flows west through Findlay and past Ottawa. The 493,434-acre (771 square mile) Blanchard River Watershed drains into the Auglaize River near the Village of Dupont in Putnam County.

Over 80% of the watershed is cropland, and over 83% of the watershed has two percent slope or less. The largest city in the watershed is Findlay. The total population in the Blanchard River Watershed is estimated to be 91,266.

Portions of six counties are found within the watershed, ranging from Hancock County (71.0%) to Seneca County (1.6%). Cities and villages situated entirely or partly in the Blanchard River Watershed include Arlington, Beaverdam, Benton Ridge, Bluffton, Columbus Grove, Continental, Dunkirk, Dupont, Findlay, Forest, Gilboa, Glandorf, Jenera, Kenton, Miller City, Mount Blanchard, Mount Cory, Ottawa, Pandora, Patterson, Rawson, Vanlue and Wharton.

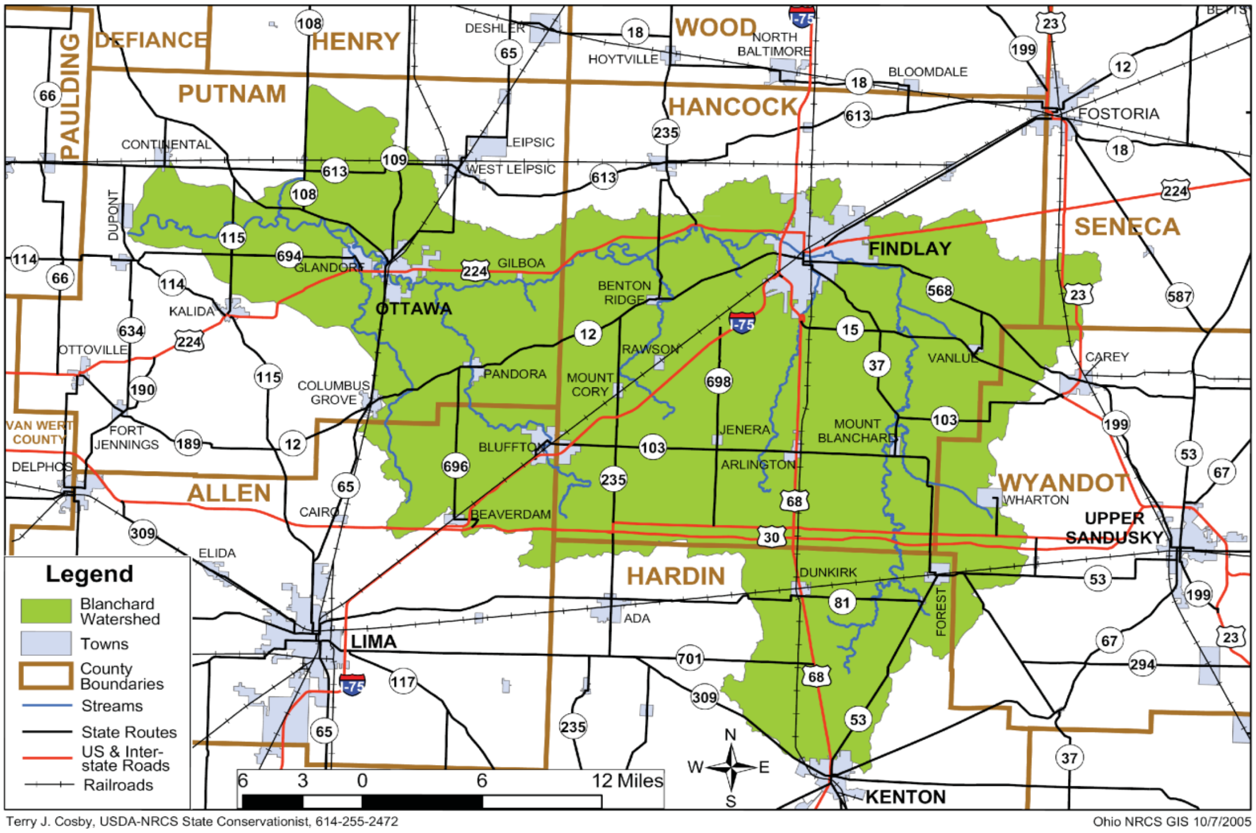


Figure 1 – Blanchard River Watershed

A detailed discussion of the hydrologic and hydraulic analyses for this study can be found in the Hydrology and Hydraulics Appendix.

4.0 GEOTECHNICAL ANALYSIS

The Blanchard River Watershed is characterized by extremely flat terrain: approximately 66 percent of the basin has a slope of one percent or less, 26 percent is characterized by slopes of between one and four percent, 7 percent of the basin exhibits slope of more than four to ten percent, and less than one percent has slopes of more than ten percent.

The highest area above mean sea level is located in Hardin County at 1,036 feet while the lowest is located in Putnam County at 677 feet. The main topographical features of the Blanchard

River basin are the Defiance Moraine (a relatively sharp topographic relief that forms the northern border of the Blanchard River watershed for a distance of 50 miles) and the Wabash Moraine (elevations generally exceeding 1,000 feet along the southern border of the basin). General slope and relief characteristics of the Blanchard River Watershed are shown in Table 1 and Figure 2.

Table 1 - Slope Characteristics of the Blanchard Watershed

Slope Class	Area (Sq. Mi.)	Percent of Watershed (%)
0-1%	501.2	66.2
>1-2%	130.3	16.9
>2-4%	91.1	11.8
>4-6%	26.9	3.5
>6-8%	26.9	3.5
>8-10%	2.8	0.4
>10%	2.1	0.3
Total:	**771.0**	**100.0**

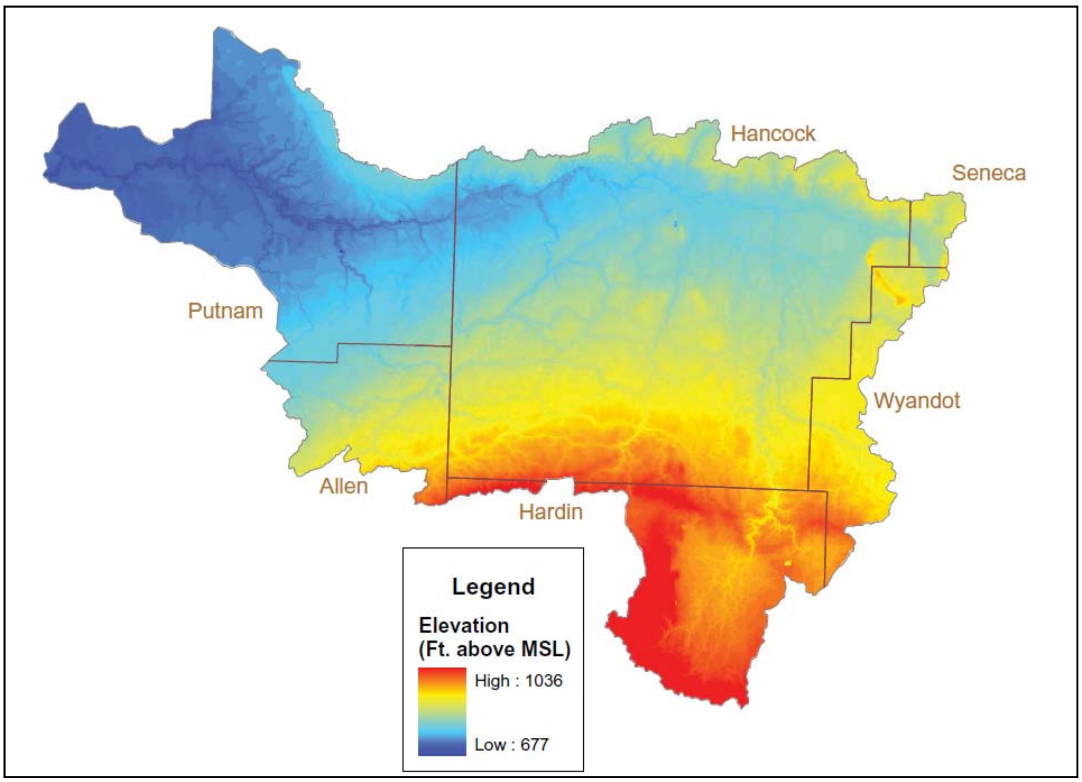


Figure 2 - Blanchard Watershed Surface Relief (NRCS)

The geotechnical analysis and evaluation associated with the plan formulation, and analyses of the Tentatively Selected Plan are discussed in the March 2013 Geotechnical Report – Supporting Documentation for the Report Synopsis – Final Array of Plans."

5.0 SURVEYING, MAPPING AND OTHER GEOSPATIAL DATA

5.1 Terrain Data

Terrain data used to develop alternatives was developed from 2006 OSIP digital LiDAR. The vertical datum for this study is the North American Vertical Datum of 1988 (NAVD). Horizontal datum is North American Datum of 1983 (NAD83).

5.2 Rock Contour Data

Historic boring data and well logs, as well as soil profiles provided by the Ohio Department of Natural Resources were used to develop a three-dimensional rock surface for calculating rock and soil excavation quantities along the various diversion alignments. The rock surface was refined using the boring data collected as part of this study. Excavated soil and rock quantities were estimated using Microstation INROADS software. The Western Diversion Channel of the Tentatively Selected Plan was developed to avoid any rock excavation.

5.3 Future Survey Needs

During the Plans & Specifications Phase, detailed topographic surveys along the proposed line of protection and in the locations of project features will be required to support detailed design drawings. Detailed utilities surveys along the line of protection and near project features will also be required.

Design drawings for construction will be prepared in accordance with ER 1102-2-1150, *Engineering and Design for Civil Works Projects* and CAD standards listed at http://www.nan.usace.army.mil/business/buslinks/contract/ae/index.htm.

Specifications will be developed for all pertinent items identified during the construction phase using UFGS files found in the SPECSINTACT automated specifications system and in accordance with ER 1110-1-8155, *Specifications*.

6.0 PRELIMINARY DESIGNS FOR ALTERNATIVES' SCREENING

Nine categories of flood risk management measures were considered for the City of Findlay and Village of Ottawa including:

- Levee and Floodwall Structures
- Detention
- Diversions / Channel Relocations
- Channel Improvements
- High Velocity Channels
- Nonstructural Measures
- Bridge Replacement/Modification
- Evacuation of the Floodplain
- Flood Warning and Emergency Measures

Preliminary designs were required in order to develop gross quantity estimates and costs to use in the plan formulation and selection. Due to the preliminary nature of the designs, several assumptions were made regarding proposed plan details. The assumptions are discussed in the subsequent paragraphs. For plans eliminated as a result of formulation, graphics or figures are typically not provided. Plans to be considered in optimization are discussed and include figures depicting conceptual layouts and designs.

6.1 Levee and Floodwall Structures

The proposed levee has a trapezoidal shape that has a ten-foot top width with 3:1 side slopes that tie into existing or proposed grades. The levee consists of an earthen fill embankment with a ten foot wide low permeability core in the middle of the structure (see Figure 3).

With heights of up to 20 feet the recommended floodwall is a Type T-Wall, 18-inches thick.

In Findlay, a levee/floodwall system was proposed along the north and south banks of the Blanchard River from I-75 upstream approximately 3.1 miles (north levee) and 3.7 miles (south levee) to Bright Road. It was determined that over 9 miles of tie-back levee would be needed to control three to four feet of induced flooding on Eagle and Lye Creeks and that this levee system was not cost effective. The required levee and floodwall alignments are shown on Figure 3A. Levee/floodwall alternatives to alleviate flooding in Findlay and induced flooding upstream of Lye Creek were eliminated due to high cost and a low Benefit-to-Cost Ration (BCR).

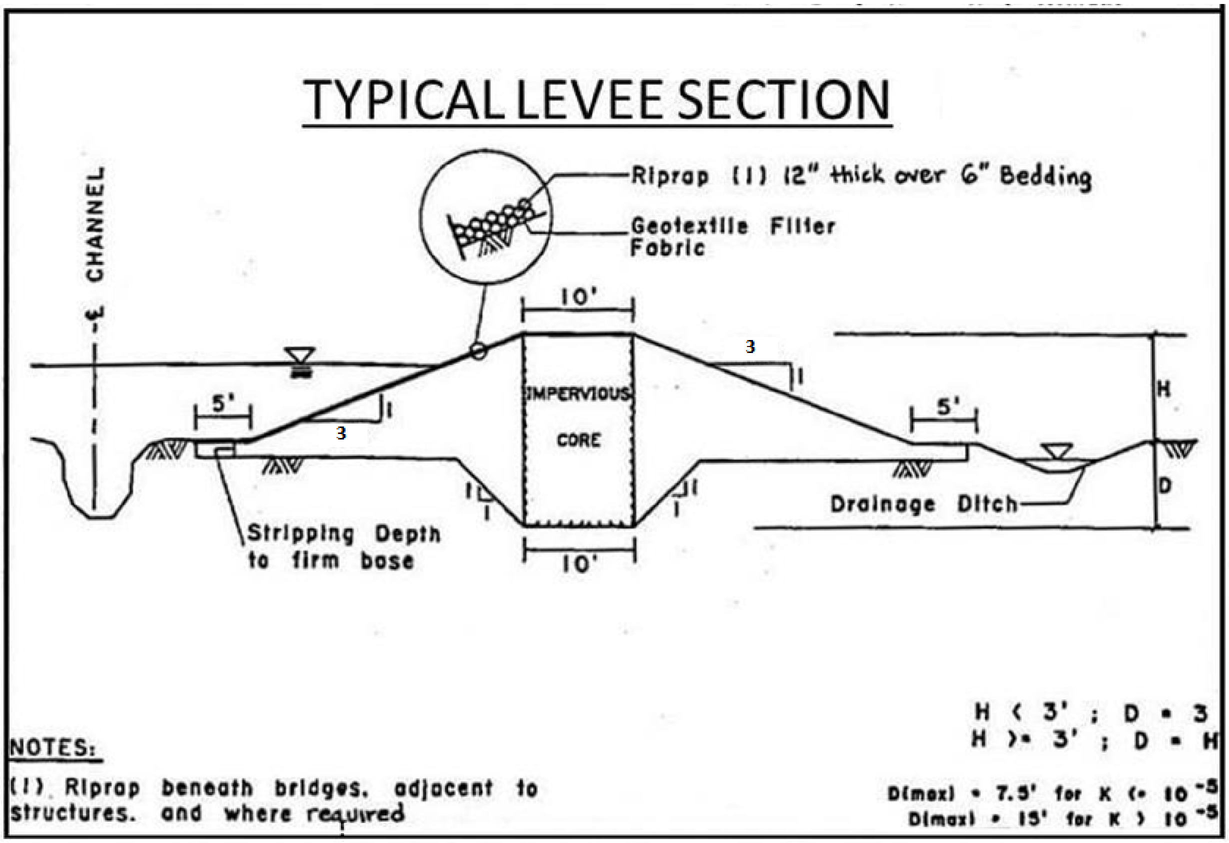


Figure 3 – Typical Levee Section

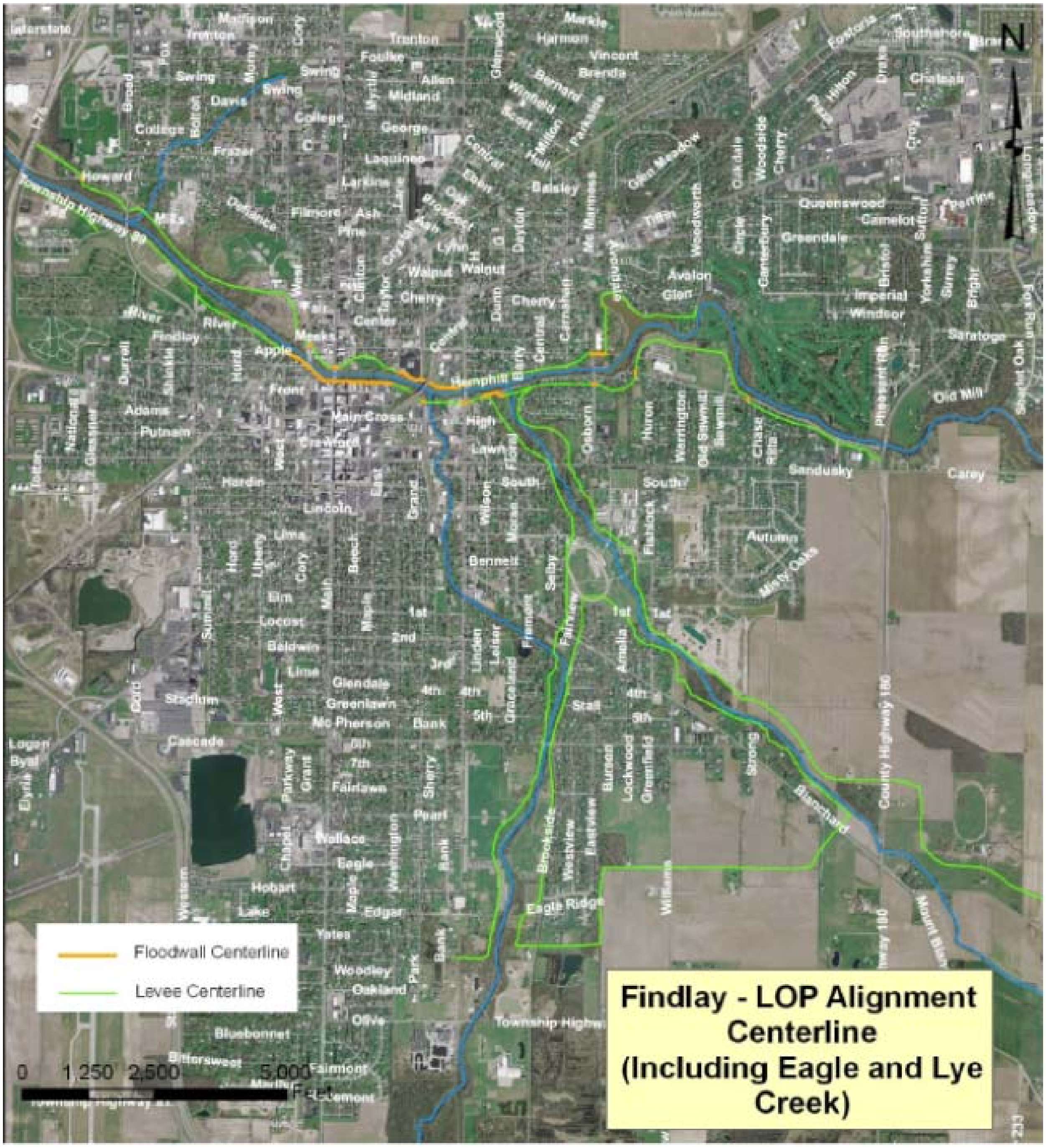


Figure 3A –Levee and Floodwall Alignments in Findlay

6.2 Detention Basins

Detention in a number of locations was identified as an effective flood risk management measure that could also provide ecosystem restoration opportunities.

6.2.1 Eagle Creek Inline Detention Structure/Dam

The inline detention structure/dam would have the same general properties as the proposed levee with an earthen fill embankment and low permeability core (25-foot wide) in the middle of the structure with 3:1 side slopes to minimize the footprint while meeting both stability and seepage criteria. The layout includes a 25-foot wide roadway to provide access onto the dam.

The dam utilizes a low flow outlet to reduce peak flow and flooding downstream, and a spillway to accommodate larger flood events including the 500-year flood and Probable Maximum Flood (PMF).

The low flow outlet will be located at the existing creek centerline. At the upstream end, the proposed culvert will include a trash rack. Downstream outlet protection will consist of riprap over filter fabric.

The proposed spillway is a Roller Compacted Concrete (RCC) step spillway with a concrete stilling basin for energy dissipation. The spillway is designed to provide approximately three feet of freeboard above the PMF. A 3-foot thick reinforced concrete wall will be required between the earthen embankment and the RCC spillway, extending to the top of the earthen section.

6.2.2 Eagle Creek Inline Diversion Structure

The inline diversion structure would consist of a control structure on Eagle Creek, an earth embankment tying into high ground on both sides of Eagle Creek, and an overflow weir. The control structure would consist of steel slide gates in concrete gatewells and concrete headwalls. The earth embankment would have a 20-foot topwidth, 1v on 3h sideslopes and a low permeability core. The overflow would be an earth berm covered with riprap with a top elevation as required by hydraulic design analysis.

6.2.3 Offsite Storage

The Blanchard River Watershed is predominantly agricultural and many of the fields are inundated shortly after the Blanchard River leaves its banks. Seven storage areas located downstream of Findlay and immediately adjacent to the Blanchard River were considered to temporarily store flood volume and reduce peak flows in the Blanchard River. The storage areas are formed using an earthen levee berm with a ten foot top width with 3:1 side slopes, as shown in Figure 3. The length of the berms ranges from 3,700 to 10,500 feet.

6.2.4 Channel Realignment and Offline Detention in Ottawa

Diversion of flood flow via high flow diversion channels 20 to 30 feet wide with 2 to 2.5:1 side slopes was considered to bypass river meander bends on the Blanchard River upstream of the I-9 Bridge and downstream of the Ottawa Reservoir to increase and accelerate flow downstream of Ottawa. In conjunction with the diversion channels, the oxbow areas bypassed by the channels were evaluated as additional flood storage. The proposed diversion channels and detention areas were evaluated as standalone measures and found not to be effective in reducing flood stage or discharge as conveyance of floodwater on the Blanchard River is limited by a flat river gradient and high backwater created by the Township Road I-9 bridge embankment.

The alternatives were also evaluated in conjunction with modification of the I-9 Bridge embankment. The combined plan removes the downstream conveyance constraint at the I-9 bridge and extends the reduction further upstream by diverting flow around the existing oxbow into a more hydraulically-efficient channel. The analysis showed that neither alternative was cost effective utilizing the existing oxbow for floodwater detention. However, further analysis showed that the proposed diversion channel without detention upstream of the I-9 bridge modification was cost effective.

6.2.5 Offline Detention Along the Western Channel Diversions in Findlay

In order to create additional temporary storage of floodwaters adjacent to the proposed diversion channels upstream of Findlay, detention berms were considered but determined not to be cost effective.

6.3 Diversion Channel Projects

6.3.1 Eagle Creek Diversion Channels

In lieu of levee and floodwall alternatives in downtown Findlay, three diversion channel alternatives including the widening and partial realignment of Aurand Run were considered in order to route floodwaters from Eagle Creek into the Blanchard River downstream of the City of Findlay, bypassing the city (see Figure 8). The proposed concept utilizes inline diversion as discussed in the previous section to redirect Eagle Creek flow into the diversion channel.

The diversion channels ranged in length from 7.4 to 9.3 miles, and included widths from 35 to 80 feet and depths from 10 to 15 feet to the top of bank. To accommodate the proposed diversion channel alignments, 37 bridges or potential bridge locations were evaluated. The assessment concluded that reconstruction of eight bridges and construction of 29 new bridges was likely required. The proposed alignments affect 28 local roads (Township and County), three interstate highways, three State roads and three railroads.

6.3.2 Blanchard to Lye Diversion Cutoff

During high flow events, a natural diversion of floodwaters occurs along the left bank of the Blanchard River upstream of the Findlay Reservoir allowing floodwaters to overtop the river bank and flow overland into Lye Creek, causing significant flood damage. A levee approximately 9,800 feet long consisting of an earthen fill embankment with a ten foot wide low permeability core, as shown in Figure 3, was considered to reduce the frequency of the diversion. The alternative reduces damage along Lye Creek but induces some flooding downstream on the Blanchard River.

Both nonstructural measures and levee/floodwall were considered to alleviate the induced flooding as a result of the diversion cutoff. The levee/floodwall option was determined not to be cost effective.

6.4 Channel Improvements

The existing channels of the Blanchard River and its tributaries have very flat slopes which would require excavation of exceptionally long reaches (partially into bedrock) to provide any substantial flood mitigation. Channel widening would be costly due to the large number of bridge replacements and impacts on other properties, and has been eliminated from further consideration. Small scale channel improvements are potential considerations for improving flow at bridges with significant head losses. Channel clearing and snagging would not result in substantial flood mitigation.

6.5 High Velocity Channel

High velocity channels have been eliminated from consideration because the flat stream gradients make them technically infeasible.

6.6 Bridge Replacement/Modification

Only two bridge and roadway modification alternatives were identified as being effective in reducing flooding. The southerly approach road onto the I-9 Bridge is elevated and functions as a dam, constricting the flow passing through the bridge and contributing to current flood problems in the Village of Ottawa. The proposed alternative removes up to eleven feet of roadway embankment elevation from an approximately 1,000 foot stretch of roadway.

In Findlay, the Norfolk and Southern Railroad Bridge in downtown Findlay significantly constrains flow. With a majority of flow in the overbank, modifying the existing bridge structure has limited impact on flood reduction. Several options were considered to improve hydraulic losses at the Norfolk Southern Railroad Bridge including adding four 10-foot diameter culverts in the overbank, and raising and/or widening the bridge. It was determined that both raising the low chord of the bridge by two feet and increasing the hydraulic opening approximately two feet provided the greatest reduction in flooding.

6.7 Nonstructural Measures

6.7.1 General

Nonstructural measures are utilized to move buildings being damaged out of the floodplain, rather than redirect the movement of water. A screening of nonstructural alternatives was undertaken to determine whether they could be implemented as a part of a cost-shared project, either standalone or as a project component, or as an element of a locally implemented Flood Plain Management Plan (FPMP). The analysis looked at property acquisition and building retrofits.

In order to evaluate nonstructural alternatives, an algorithm was applied to evaluate six nonstructural measures. The measures considered were: (1) wet floodproofing, (2) dry floodproofing, (3) elevation, (4) acquisition or buyout, (5) floodwalls for individual buildings, and (6) rebuilding. The measures are discussed in detail in the following section.

6.7.2 Retrofitting

The four retrofitting measures are described below:

1. Dry Floodproofing. Dry Floodproofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure walls. Dry floodproofing measures considered in this screening make the portion of a building that is below the flood level watertight by attaching watertight closures to the structure in doorway and window openings. Dry floodproofing is typically limited to approximately three feet in height due to the hydrostatic pressures exerted on structures by that depth of flood water.

2. Wet Floodproofing. Wet Floodproofing measures allow flood water to enter lower, non-living space areas of the structure via vents and openings to reduce hydrostatic pressure and in turn reduce flood-related damages to the structure's foundation. This technique can be used along with the protection of utilities and other critical equipment, which can include permanently raising machinery, critical equipment, heating and cooling units, electrical outlets, switches, and panels and merchandise/stock above the design floodwater height. It can also involve construction utilizing flood resistant materials.

3. Elevation. Raising the lowest finished floor of a structure to a height above the design flood level. This option was considered both as a standalone measure and in conjunction with additional construction. In some cases, the structure may be lifted in place and foundation walls extended up to the new level of the lowest floor. In other cases, the structure may be elevated on piers, posts, or piles.

4. Floodwalls for Individual Buildings. Detached levees and floodwalls were not considered due to the density of structures in the floodplains.

5. Rebuild. Rebuilding refers to demolishing a flood-prone structure and replacing it with a new structure built to comply with local regulations regarding new construction and substantial improvements in a floodplain, and therefore, is at a lower risk. This is not technically a retrofit; however, the result is a similar structure located within the same floodplain, elevated to comply with floodplain management regulations. The rebuild option is typically considered only where the costs were found to be less than those associated with other retrofitting measures.

6.7.3 Evacuation of the Floodplain

Evacuation of the floodplain effectively reduces flood damage but is not cost-effective or realistic as a comprehensive solution. Evacuation can be accomplished by simple acquisition and demolition of the structure, or may be involve relocation of a structure on the property but out of the floodplain. In some locations, evacuation may be more appropriate than other nonstructural measures and may provide additional restoration or recreation opportunities. One specific area for potential evacuation is along the right bank of the Blanchard River between Main Street and the Norfolk & Southern Rail Bridge. Acquisition in this area would complement existing acquisition efforts by the City of Findlay, creating a more efficient floodway and allowing an extension of the existing riverfront park and walkway.

6.7.4 Flood Warning and Emergency Measures

Updated flood warning measures have recently been implemented and no further analysis is proposed.

Three separate alternatives were considered to provide a 100-year level of protection (plus freeboard) corresponding to the baseline-condition landward limits of the 10-, 25- and 100-year floodplains. After evaluating the six potential measures for each floodprone building, the least-cost measure deemed technically feasible was selected.

7.0 PLAN FORMULATION RESULTS

7.1 City of Findlay

The Tentatively Selected Plan (TSP) for the City of Findlay reduces flooding in Findlay by utilizing both structural and nonstructural measures. The structural components include: Diversion of Eagle Creek flow around the City of Findlay and a Containment Levee along the Blanchard River that limits diversion of floodwater overland to Lye Creek. See Figure 4 at the end of the appendix for an overall view of TSP; the remaining figures at the end of the appendix provide details on each of the structural components of the TSP. Nonstructural measures are discussed in the Economics Appendix of this report. The structural flood risk reduction measures are described below:

7.1.1 Eagle Creek - Inline Diversion Structure

The proposed diversion structure at Eagle Creek is located approximately 1,375 feet downstream of County Road 45 (see Figures 5, 6 and 7) and will be used to control the amount of flow diverted to the diversion channel. As flood water levels rise, slide gates in the control structure on Eagle Creek would be closed as necessary to pool water and divert it into the western diversion channel. The control structure would consist of two 8-foot wide by 6-foot high slide gates inside concrete gatewells, two 8-foot wide by 6-foot high concrete box culverts, and up and downstream retaining structures and riprap (see Figure 7). An earth embankment with a top elevation of 806 approximately 925 feet long would be constructed inline with the control structure to allow water to pool. The east end of the earth embankment would tie into the existing 806 ground surface contour and the west end would tie into the earth berm that runs along the diversion channel. The earth embankment would have a minimum 20-foot top width and 1v on 3h sideslopes. A 500-foot long trapezoidal earth/riprap overflow weir with a crest at EL. 800 would be constructed just upstream of the start of the western diversion channel to allow water from Eagle Creek to flow into the diversion channel when it reaches and exceeds EL. 800. The area between the overflow weir and Eagle Creek would be sloped to drain towards Eagle Creek and cleared of all trees and other woody vegetation. The final design of all earth structures for required stability, seepage control and erosion resistance will be done in the PED phase of the project. The extent of the earth embankment crest pool and 100-year pool are shown on Figure 6.

7.1.2 Diversion Channel

Several alignments were considered for the proposed channel diversion (see Figure 8) including West Diversion Alternative 1, which starts approximately 3,000 linear feet downstream of Route 49; the Aurand Run Alternative, located approximately 100 linear feet downstream of Route 49; and West Diversion Alternative 2 which originates at Eagle Creek approximately 1,375 linear feet downstream of County Road 45. Alignment considerations included, but were not limited to:

- Minimize or eliminate rock excavation,
- Minimize impacts to existing farm fields,
- Minimize impacts to known environmental features,
- Minimize impacts to residential/farm structures,
- Size the channel to carry sufficient flow to meet project goals (limit flooding), and
- Ensure alignment supports sufficient channel grade.

The West Diversion Alternative 1 alignment was eliminated from consideration based upon the existing terrain at Eagle Creek which is too low to support an Inline Diversion Structure. The other two diversions: Aurand Run and West Diversion Alternative 2 were evaluated for Economic and Social Effects, Residual Risks and Environmental Considerations.

Since the economic benefits of Aurand Run and West Diversion Alternative 2 plans were found to have similar BCRs, the TSP was selected based primarily on environmental considerations. The Aurand Run alignment would have included channelization of environmental sensitive areas within Aurand Run, including widening 30,000 feet of existing channel and impacting 14 acres of wetland through the excavation of over two million cubic yards of soil and one million cubic yards of rock. Environmental permitting of the Aurand Run alignment was expected to be extremely challenging. Plans were developed for West Diversion Alternative 2 using 50-year, 100-year and 250-year Eagle Creek flows in order to determine costs and BCRs for each. The plan using the 100-year flow resulted in the highest BCR and was selected as the TSP.

The tentatively selected alignment of the Eagle Creek diversion channel (see Figure 4) maximizes the drainage area controlled by the diversion. The proposed diversion channel alignment begins at Eagle Creek approximately 1,300 feet downstream of County Road 45 and flows in a westerly direction across County Road 45 and Township Roads 77, 76 and 67. The alignment then changes course approximately 500 feet to the west of Township Road 67, where it follows a northerly route across Township Road 50 and Interstate 75. The channel then turns again toward the west and continues across County Roads 9 and 313, the Norfolk Southern Railroad and Township Road 10. The alignment then curves back north approximately 1,400 feet to the west of Township Road 10, where it runs parallel to and crosses Township Road 130 approximately 2,800 to the south of Township Road 89. After crossing Township Road 130 the channel continues along a northerly path and discharges into the Blanchard River approximately 1,600 feet to the west of Township Road 130 after crossing Township Road 89. Elements of the diversion channel include:

(1) The proposed channel (see Figure 9) has the following properties:

- Channel Length: 9.4 miles
- Channel Shape: Trapezoidal
- Bottom Width: 35 to 47 feet
- Depth: 10 to 16 feet
- Side Slopes: 4H:1V
- Channel grade: 0.015 to 0.215%

(2) A berm with the following properties will be constructed alongside the diversion channel where necessary to obtain the minimum channel depth:

- Berm Top Width: 10 feet
- Berm Height: Varies
- Side Slopes: 3H:1V

(3) Over 2.1 million cubic yards of excavated soil will be hauled from the site to an existing quarry located in downtown Findlay for placement. The bottom profile of the channel has been located to avoid rock excavation.

(4) Fish & Wildlife Facilities (stream and wetland mitigation, see the Environmental Appendix of this report for further details).

(5) A permanent easement of 25 feet on both sides of the channel and the channel footprint will be required. This easement will allow for movement of maintenance vehicles after construction of the project is completed. Access will be obtained from all local, county and State roads which cross over the proposed diversion channel. During construction, permanent and temporary easements will provide access for equipment and vehicles.

Table 2 – Western Diversion Channel Bottom Profile & Cross Section Geometry

Station	Bottom Elevation	Bottom Slope	Channel Bottom Width	Channel Depth	Channel Sideslopes
0+00	750.0				
		0.083%	36’	12’	1V on 4H
60+00	755.0				
		0.215%	35’	10’	1V on 4H
180+00	780.78				
		0.076%	39’	12’	1V on 4H
265+00	787.22				
		0.015%	47’	16’	1V on 4H
342+00	788.34				
		0.038%	37’	14’	1V on 4H
491+53	794.0				

The West Diversion alignment (see Figures 11 thru 19) was established based on available HTRW documentation to avoid known sites; review of soil and rock maps, and aerial mapping; and review of property information to minimize property and structure impacts. The alignment may be refined in the future to avoid abandoned wells (exact locations are not known), bridge approaches based on structural and hydraulic analysis and for other unforeseen site conditions. An allowance for temporary and permanent relocation of fiber optic lines was included in the cost estimate. Impacts from other utilities are not anticipated to be extensive.

7.1.3 Diversion Channel Bridges and Dry Crossings

The diversion channel alignment crosses Township Roads 89, 130, 10, 50, 77, 76, 67 and 49; County Roads 9, 313, 84 and 86; State Road 12, Interstate 75 and the Norfolk Southern Railroad. Seven township roads (89, 130, 10, 50, 77, 76 and 49) would cross the diversion channel using dry crossings or would be dead-ended, the decision to cross or dead-end the township roads will be made in the PED phase. Eight new bridges are necessary to accommodate the proposed diversion channel where it crosses Township road 67, County Roads 9, 313, 84 and 86; State Road 12, Interstate 75 and the Norfolk Southern Railroad. The bridge layouts were developed using ODOT's Location and Design Manual and available traffic data.

7.1.3.1 Dry Crossings

Dry crossings would consist of the road ramping down the diversion channel sideslopes, crossing the channel bottom and then ramping back up the channel sideslopes. The channel sideslopes would be flattened to a 10 percent grade at the dry crossings. All dry crossings would be paved with asphalt along the channel sideslopes and bottom. During flood events, the dry crossings would be physically closed to traffic by means of gates lowered across the road of both sides of the channel.

7.1.3.2 Local Road Bridges

Local road bridges (see Figure 21) were designed so that the structure would clear the top of the channel embankment by a minimum of one foot. In deep channel areas with no embankment the structure was designed to clear the minimum channel depth by one foot. Bridge widths were determined using ODOT's Location and Design Manual or estimated where no traffic data was available. The effects of skew for all structures were found to be less than 15 degrees except for Township Road 130 with a 45 degrees skew.

The bridge structure type developed for the local roads is a three span prestressed concrete beam on concrete stub abutments, and cap and column piers except Township Road 103, which was determined to be cast in place concrete slab due to its high degree of skew. The foundation will be drilled shafts socketed into bedrock.

Local bridge structures have the following properties:

- Bridge Lane Width: 11 feet
- Bridge Shoulder Width: 4 feet
- Spans: 3 feet
- Bridge Skew: up to 45 degrees
- Cross Slope: 1.6%
- Bridge Width: 30 to 44 feet
- Channel Bottom Width: 45 to 80 feet
- Channel Top Width: 129 to 186 feet

7.1.3.3 State Road Bridge

The state road bridge structure (see Figure 22) was designed using the same criteria developed for the local bridge structures including channel depth and embankment clearance and taking into account the effect of skew.

The structure type developed for the state road crossings is also a three span prestressed concrete beam on concrete stub abutments and cap and column piers with drilled shafts socketed into bedrock foundation. The state bridge structure has the following properties:

- Bridge Lane Width: 12 feet
- Bridge Shoulder Width: 10 feet
- Spans: 3 to 5
- Bridge Skew: None
- Cross Slope: 1.6%
- Bridge Width: 44 feet
- Channel Bottom Width: 45 to 80 feet
- Channel Top Width: 163 feet

7.1.3.4 Interstate Highway Bridge

The interstate highway bridge (see Figure 23) was also designed assuming one foot of clearance, effect of skew and utilizing ODOT's Location and Design Manual.

The bridge structure type developed for the interstate highway crossings is a twin four span cast-in-place slab, with concrete stub abutments, and cap and wall piers. The foundations are drilled shafts socketed into bedrock at the abutment and spread footing on rock for the piers. The interstate bridge structure has the following properties:

- Bridge Lane Width: 12 feet
- Bridge Shoulder Width: 12 feet
- Spans: 4
- Bridge Skew: 35 degrees
- Cross Slope: 1.6%
- Bridge Width: 48 feet
- Channel Bottom Width: 80 feet
- Channel Top Width: 164 feet

7.1.3.5 Railroad Bridge

To accommodate the proposed railroad bridge the existing profile needs to be raised an estimated 3.5 feet. The bridge structure type (see Figure 24) developed for the railroad crossing is a three span steel girder on reinforced concrete substructures. The foundations will be spread footings on bedrock. The railroad bridge structure has the following properties:

- Spans: 3
- Bridge Skew: 15 degrees
- Cross Slope: 1.6%
- Bridge Width: 48 feet
- Channel Bottom Width: 80 feet
- Channel Top Width: 164 feet

7.1.4 Utility Relocation

7.1.4.1 <u>Fiber Optic Lines</u>

Based on available information, approximately six underground fiber optic lines are located along Township Roads 50, 67 and 76 and County Roads 9 and 313. Many of these cross the proposed diversion channel alignment and need to be temporarily moved, protected and relocated onto the new bridges or buried beneath the channel grade at road dry crossings or dead-ends.

7.1.4.2 <u>Abandoned Oil Wells</u>

Based on available information, abandoned oil wells are anticipated to impact most of the proposed diversion alignment. Once the actual well locations have been identified the proposed alignment could be adjusted to reduce the number of wells impacted, if necessary. All wells located within and adjacent to the proposed diversion channel footprint will need to be closed and/or removed.

7.1.4.3 Oil <u>Pipelines</u>

Based on the National Pipeline Mapping System map viewer, there are oil pipelines that cross the proposed diversion alignment in four locations. Some of these locations may involve multiple pipes. These pipelines would have to be relocated deeper so that they below the finished grade of the diversion channel.

7.1.5 Blanchard to Lye Diversion Cutoff Levee

The Blanchard River to Lye Creek Diversion Cutoff Levee (see Figure 20) is approximately 9,300 feet long with a 10-foot wide impervious core. The alignment follows the left bank of the Blanchard River from the Findlay Reservoir across County Road 205 to Township Road 173 and from Town Road 173 to State Road 15. The levee alignment shown on Figure 20 is preliminary, final alignment could be anywhere within the area marked "Potential Levee Location" based on project requirements. The proposed levee reduces flood damage along Lye Creek by preventing additional diverted flow from the Blanchard River from entering the creek. However, because the flow in the Blanchard River would no longer be reduced by diversion, the cutoff is expected to induce some downstream flooding along the Blanchard River. Nonstructural retrofits were identified to mitigate the effects of induced flooding.

The levee cutoff has the following properties:

(1) Dimensions:

- Top Width: 10 feet
- Top Elevation: 797.4 to 799.9 feet NAVD
- Maximum height above grade: 9 feet
- Side Slopes: 3H:1V

(2) To meet the proposed Line of Protection (LOP) and eliminate the need for a closure structure, County Road 205 will be raised six feet. The roadway approach will be regraded at a slope of 3% to meet the proposed Line of Protection.

(3) A minimum permanent easement of 15 feet on both sides of the levee footprint will be required. This easement will allow for movement of maintenance vehicles after construction of the project is completed. Access will be obtained from County Road 205, Township Road 173 and State Road 15. During construction, permanent and temporary easements will provide access for equipment and vehicles.

7.1.6 Nonstructural Mitigation

The development and discussion of the nonstructural components for the Tentatively Selected Plan are presented in the Economics Appendix of this report.

8.0 OPTIMIZATION OF THE SELECTED PLAN

Optimization of the tentatively selected plan is pending and will include locating and sizing of the various project features of the western diversion channel and Blanchard to Lye Diversion Cutoff Levee.

9.0 ADDITIONAL ANALYSES AND DATA COLLECTION

Additional analyses and data collection are required to finalize plan selection and develop a final project cost estimate. These work efforts will be conducted as part of the next phase of the Feasibility Study or during the development of Plans and Specifications (P&S) and include:

1) Identification of the location and plans for the fiber optic cables expected to be impacted by the diversion alignment.

2) Identification of the number, location, and strategy for addressing the old oil wells and active oil pipelines potentially impacted by the diversion alignment.
3) Design analysis of the various project structures.
4) Additional geotechnical borings as needed for P&S development.

10.0 PERMITS & APPLICATIONS

Permits and applications will be identified once the Recommended Plan has been determined and will be included with the development of Plans and Specifications of the Authorized Plan.

11.0 EMERGENCY ACTION PLAN

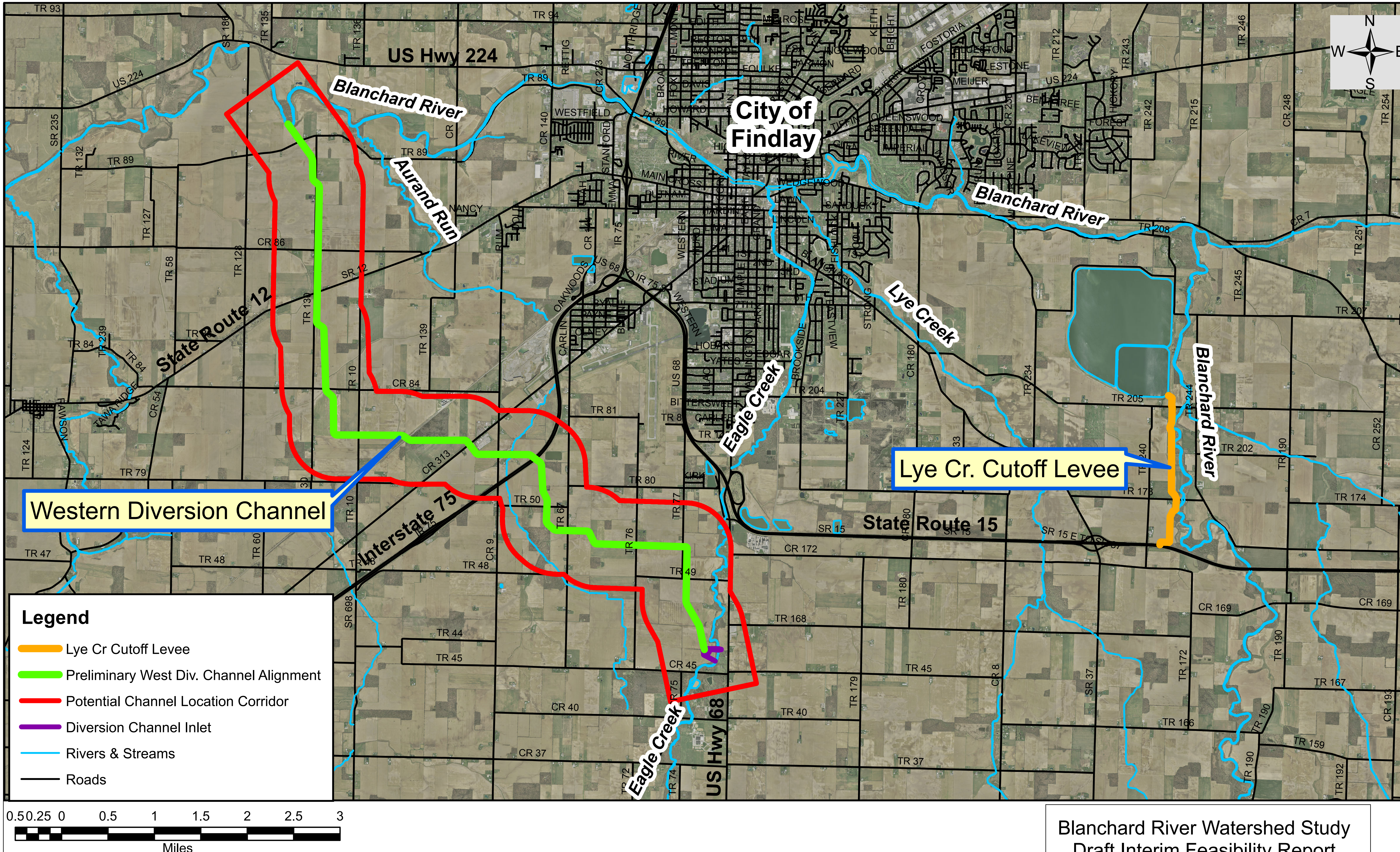
An Emergency Action Plan (EAP) will be developed during the Plans and Specifications Phase of the project. The coordination of this effort will include the non-Federal partner, county and municipalities.

12.0 OPERATION AND MAINTENANCE

Development of an Operation, Maintenance, Repair, Replacement and Rehabilitation Manual (OMRRR) will be performed during the Construction Phase of the project.

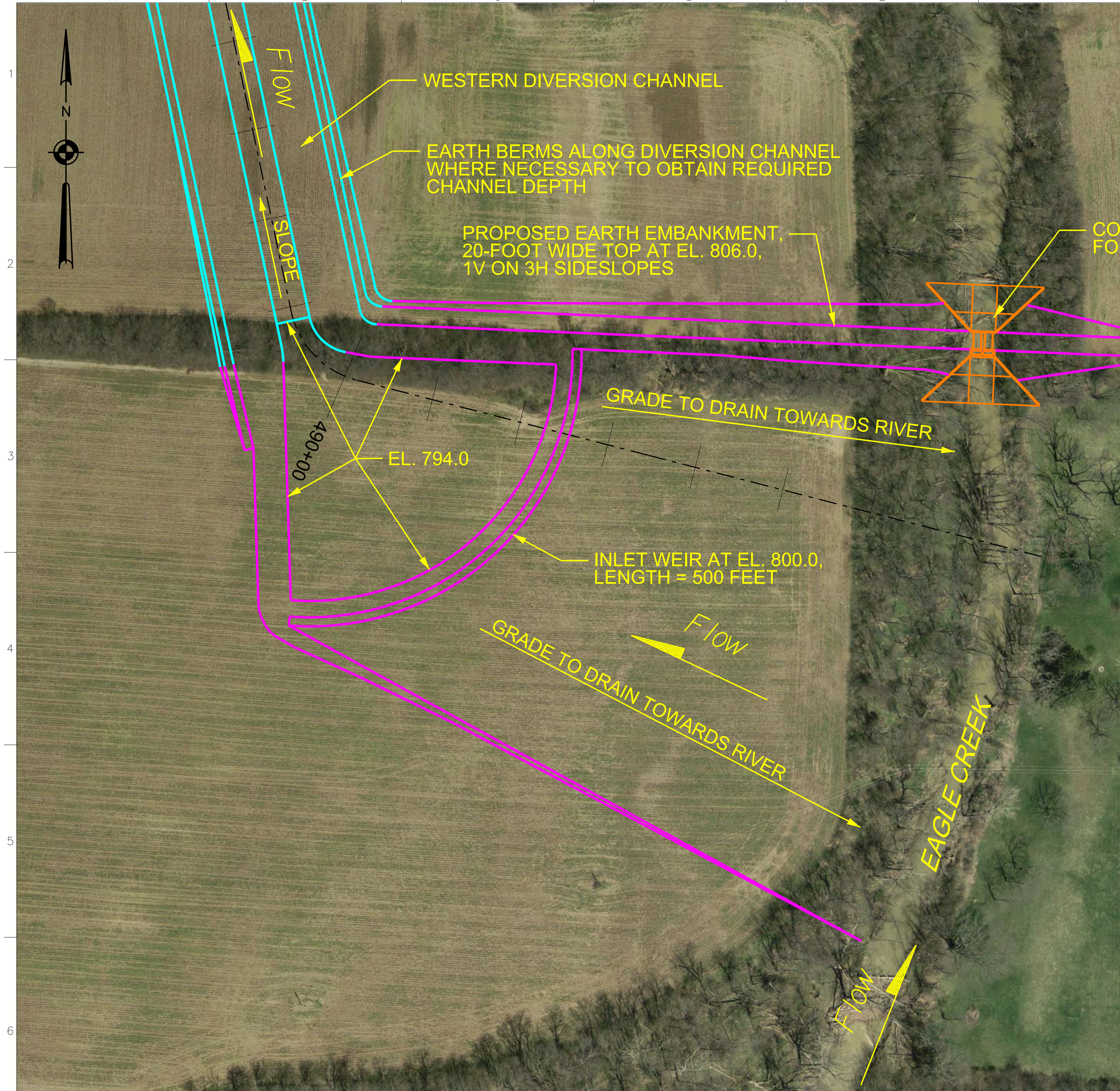
13.0 SCHEDULE FOR DESIGN AND CONSTRUCTION

Preliminary schedule for design and construction will be developed and included in the Final Interim Feasibility Study Report.



Blanchard River Watershed Study
Draft Interim Feasibility Report

Figure 4: Tentatively Selected Plan
December 2014



60' 30' 0 60'
SCALE: 1'' = 60'-0"

U.S. ARMY ENGINEER DISTRICT
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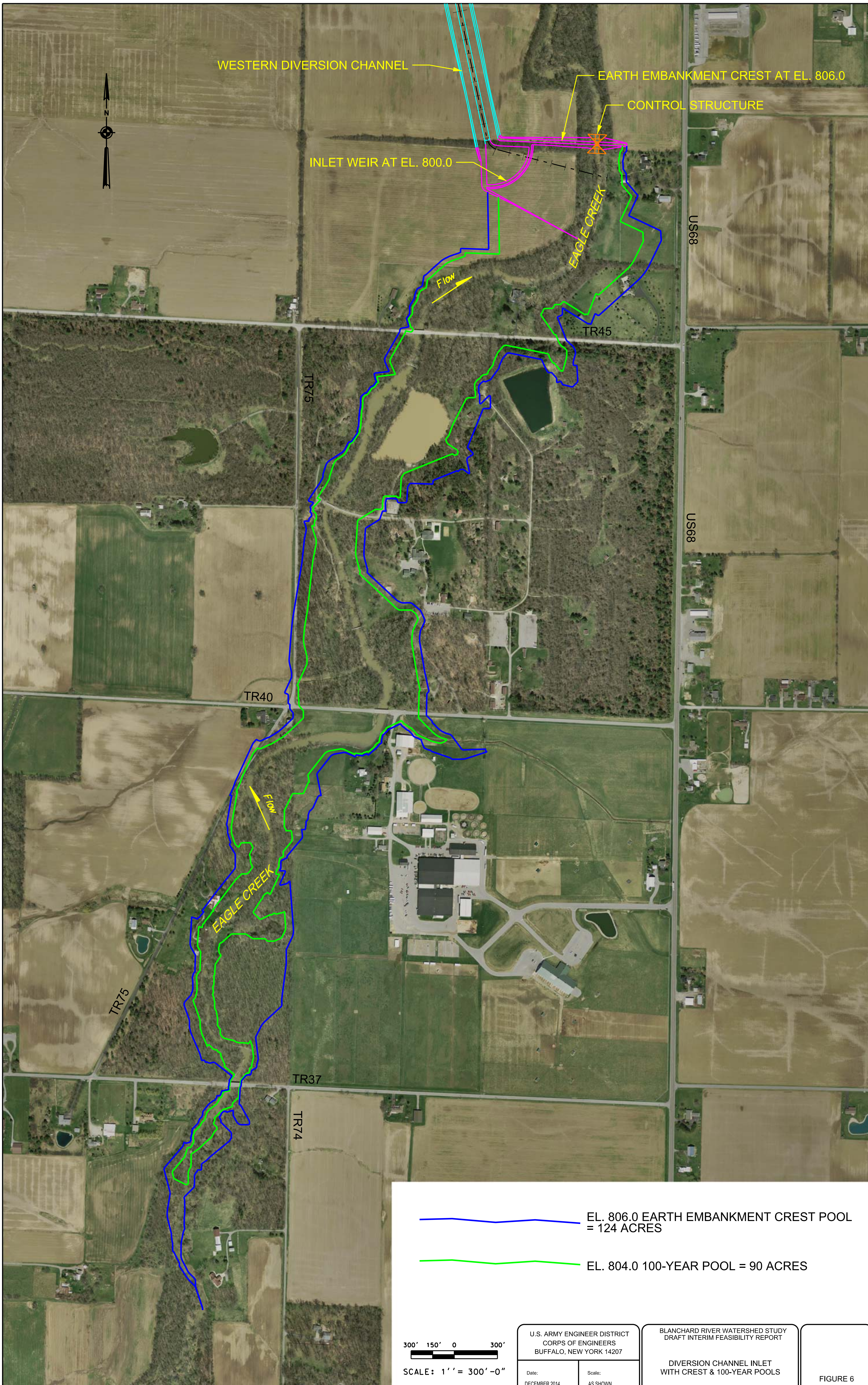
BUFFALO, NEW YORK 14207

Date: DECEMBER 2014
Scale: AS SHOWN

BLANCHARD RIVER WATERSHED STUDY
DRAFT INTERIM FEASIBILITY REPORT

WESTERN DIVERSION CHANNEL
INLET AT EAGLE CREEK

FIGURE 5



U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NEW YORK 14207

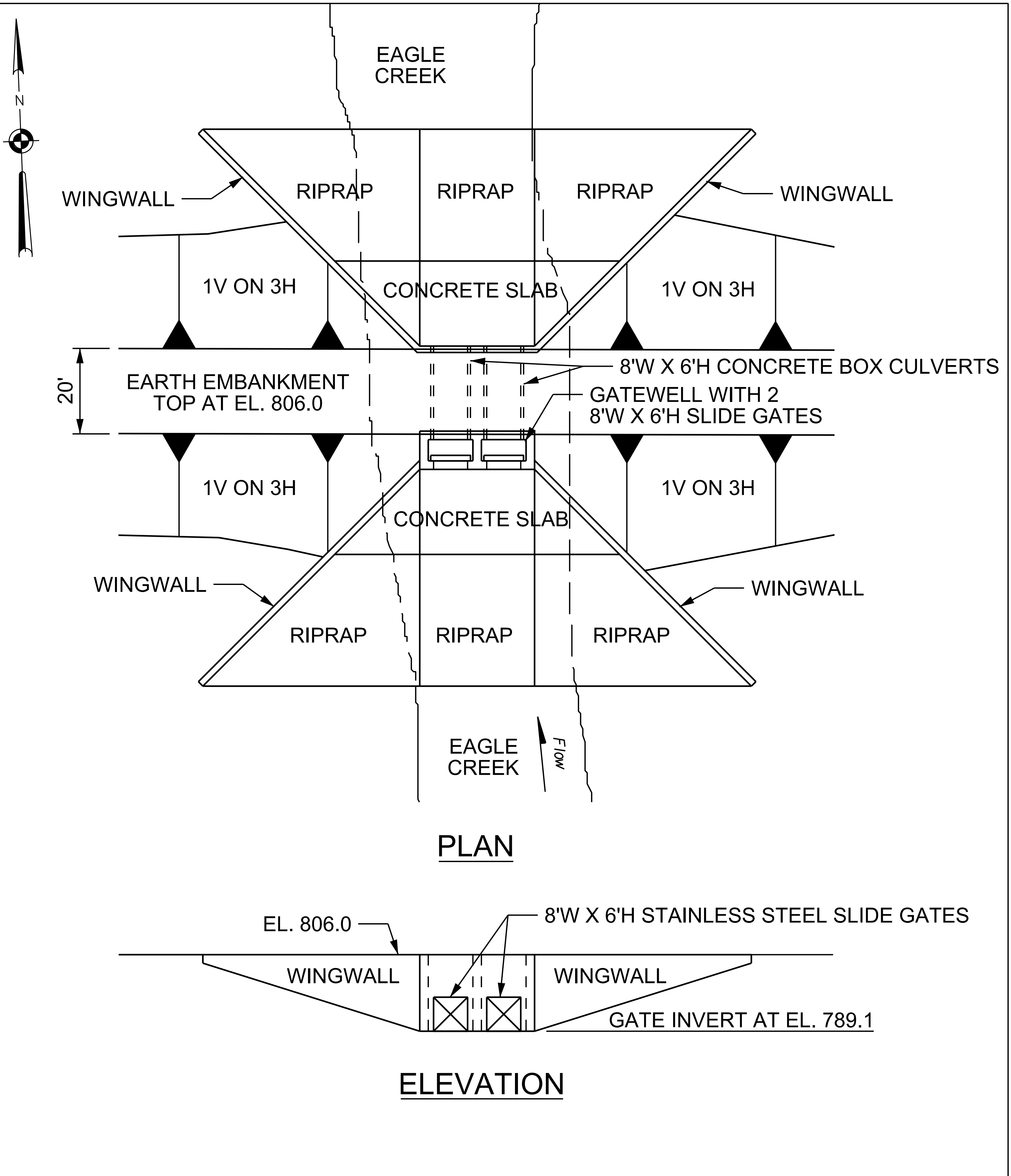
Date: DECEMBER 2014

Scale: AS SHOWN

BLANCHARD RIVER WATERSHED STUDY
DRAFT INTERIM FEASIBILITY REPORT

DIVERSION CHANNEL INLET
WITH CREST & 100-YEAR POOLS

FIGURE 6



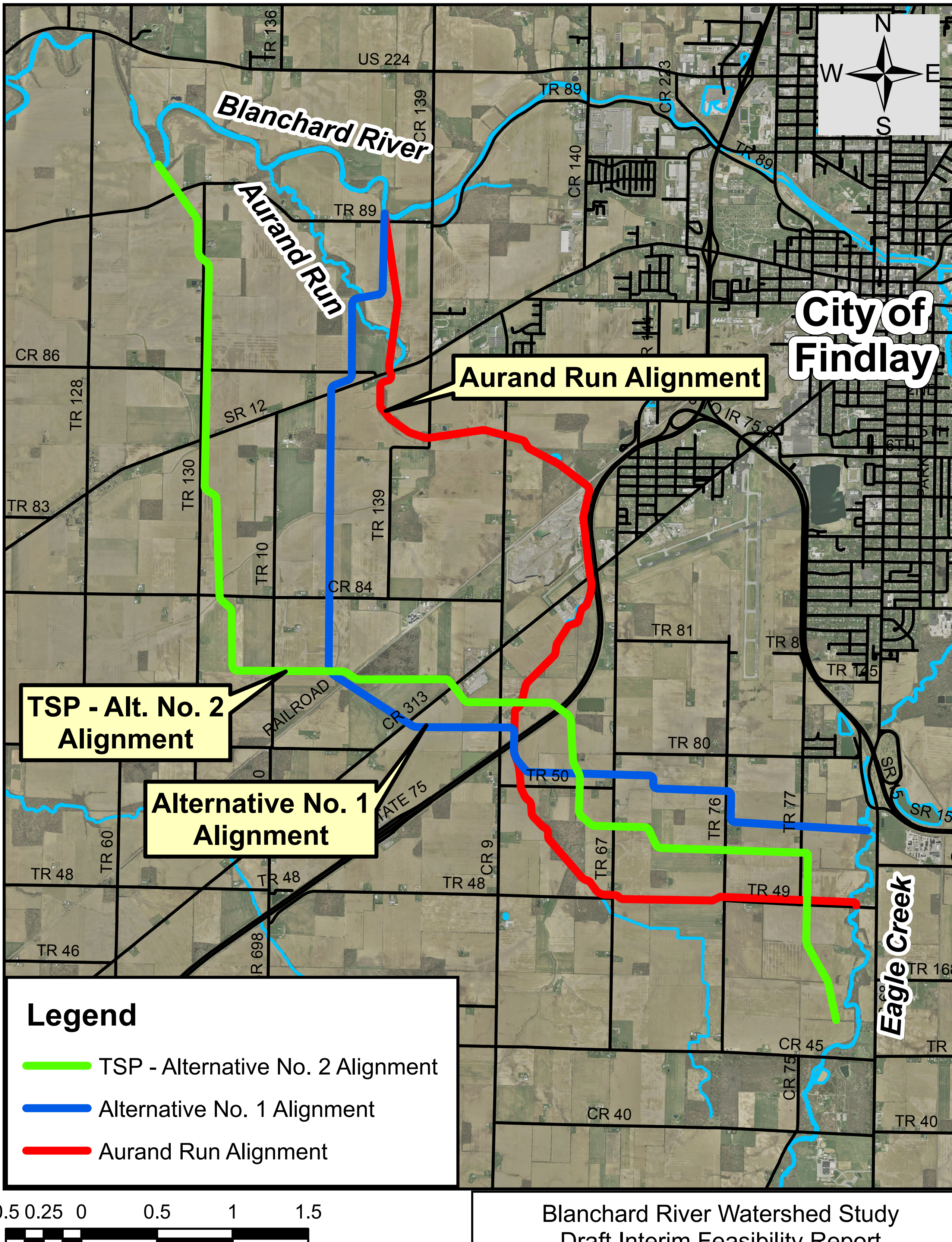
30' 20' 10' 0 30'

SCALE: 1'' = 30'-0"

Blanchard River Watershed Study
Draft Interim Feasibility Report

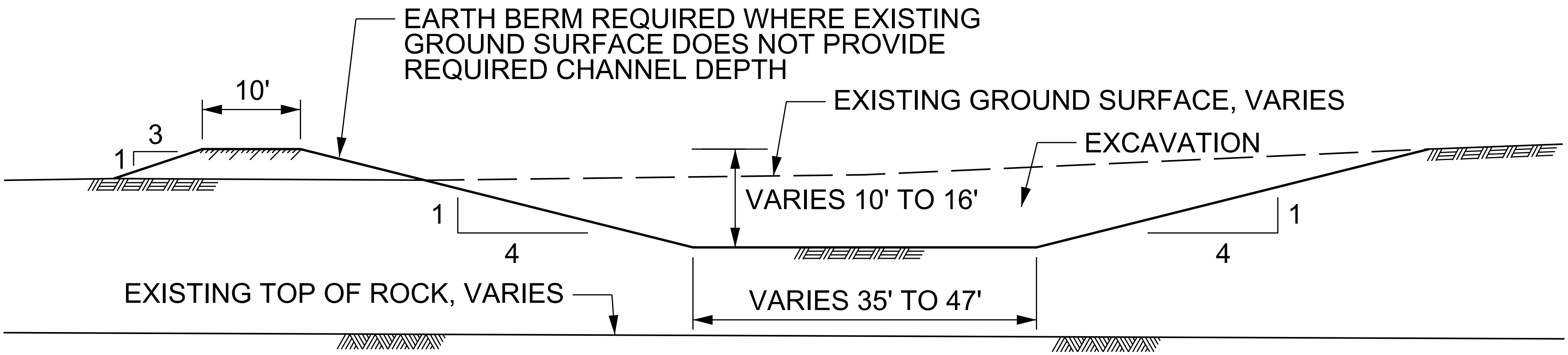
Figure 7:
Eagle Creek Control Structure

December 2014



Blanchard River Watershed Study
Draft Interim Feasibility Report

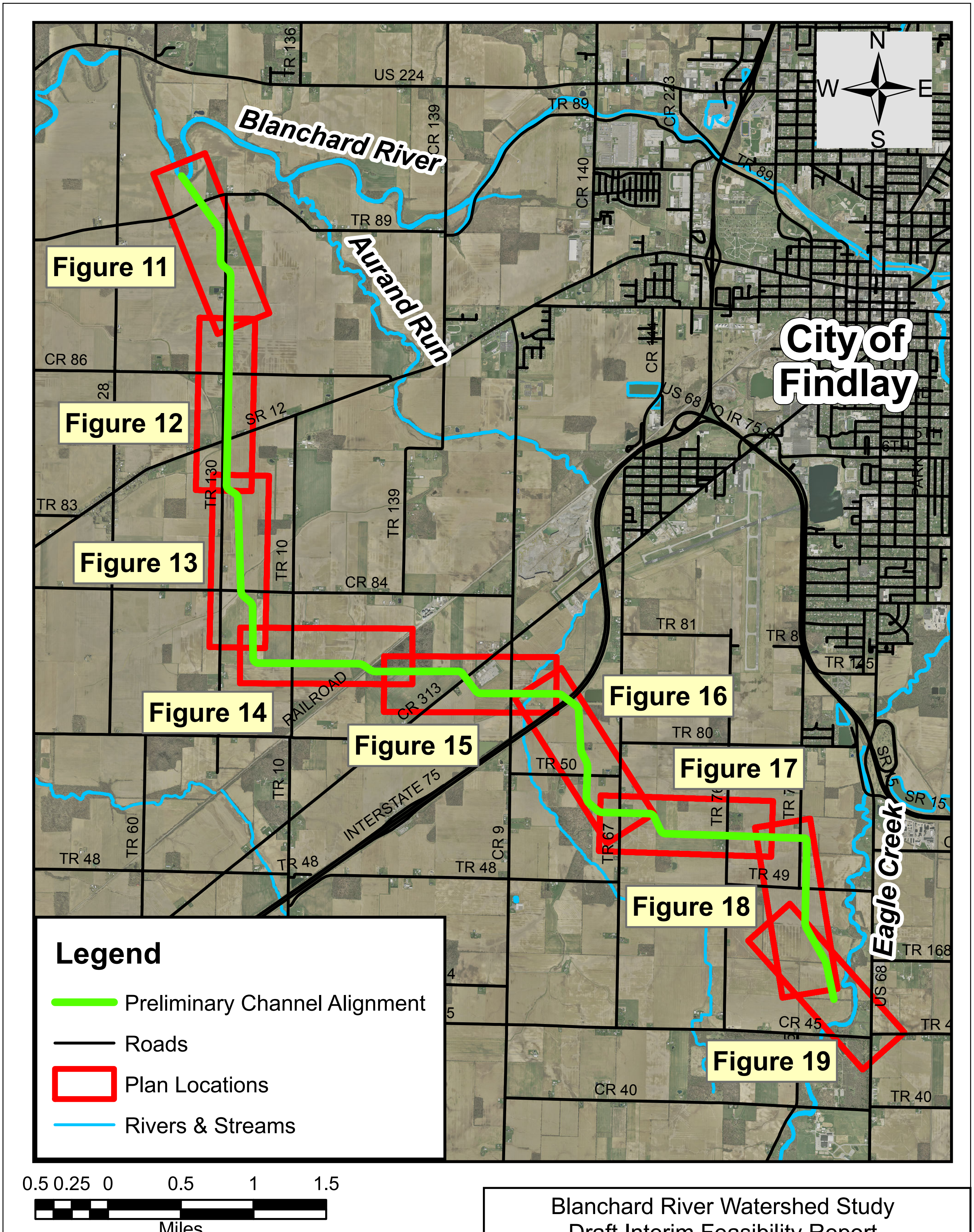
Figure 8:
Western Diversion Channel
Alternative Alignments
December 2014



TYPICAL CROSS SECTION
WESTERN DIVERSION CHANNEL

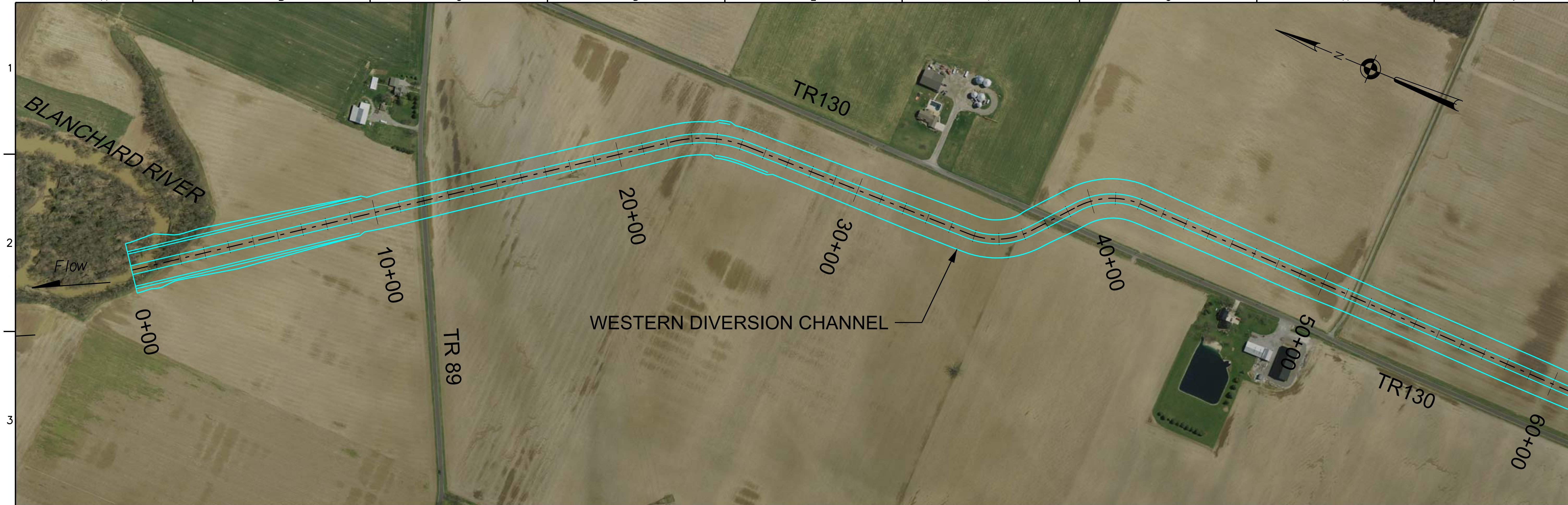
Blanchard River Watershed Study
Draft Interim Feasibility Report

Figure 9
Western Diversion Channel
Typical Cross Section



Blanchard River Watershed Study
Draft Interim Feasibility Report

Figure 10:
Western Diversion Channel - Plan Key
December 2014

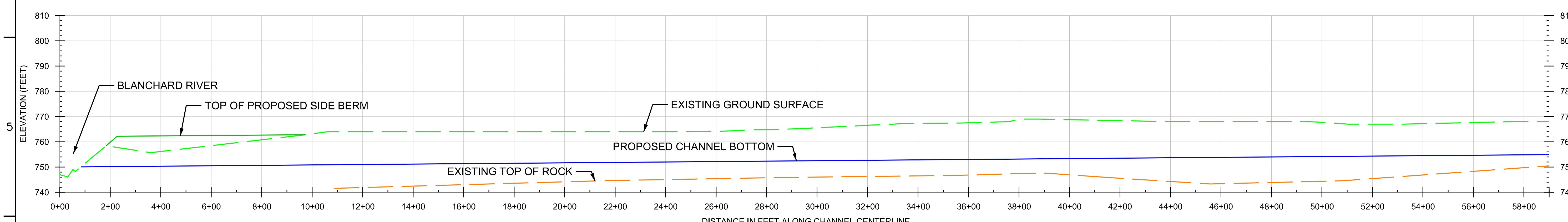


PLAN

200' 100' 0 200'

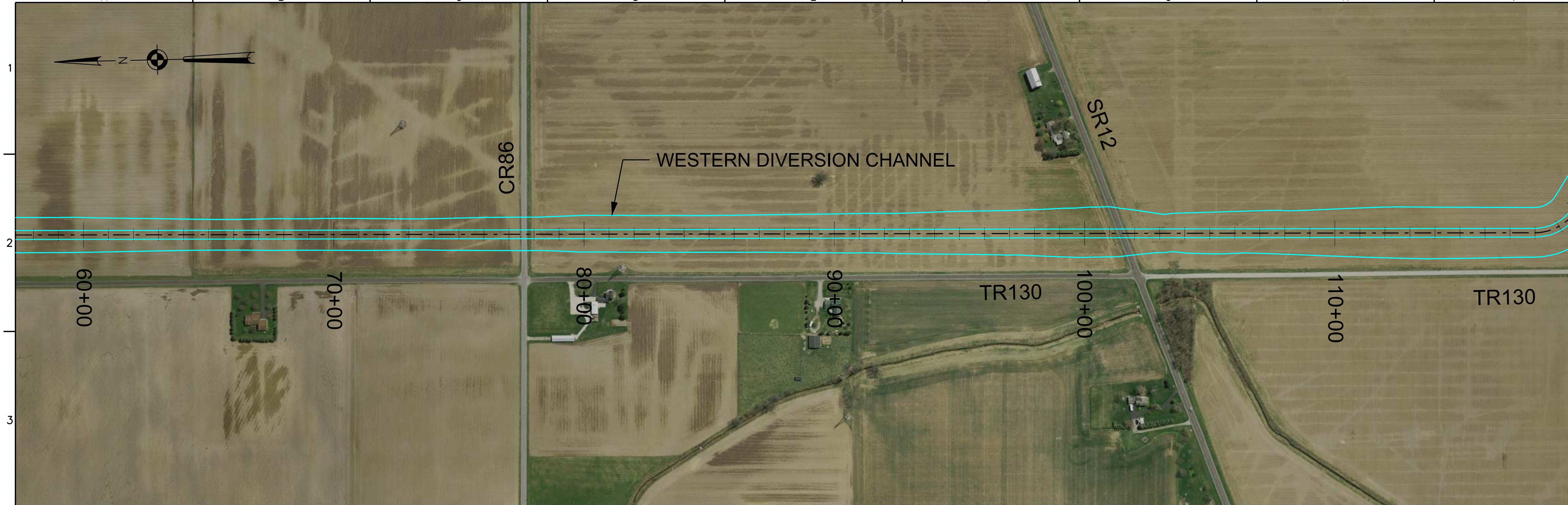
SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207 Date: DECEMBER 2014 Scale: AS SHOWN	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 0+00 TO STA. 59+00	FIGURE 11

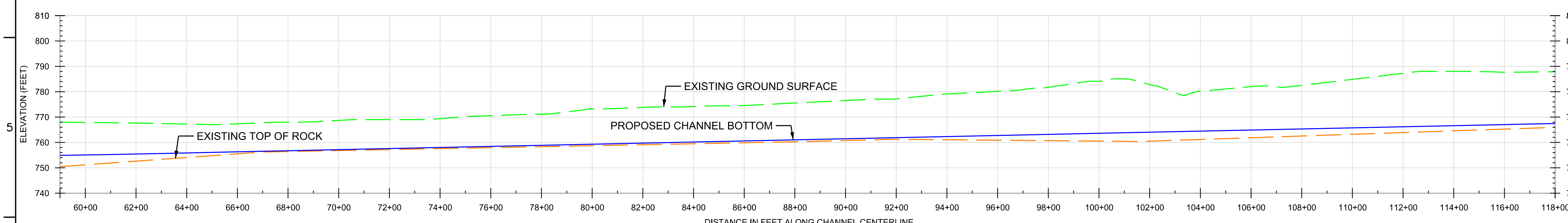


PLAN

200' 100' 0 200'

SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT
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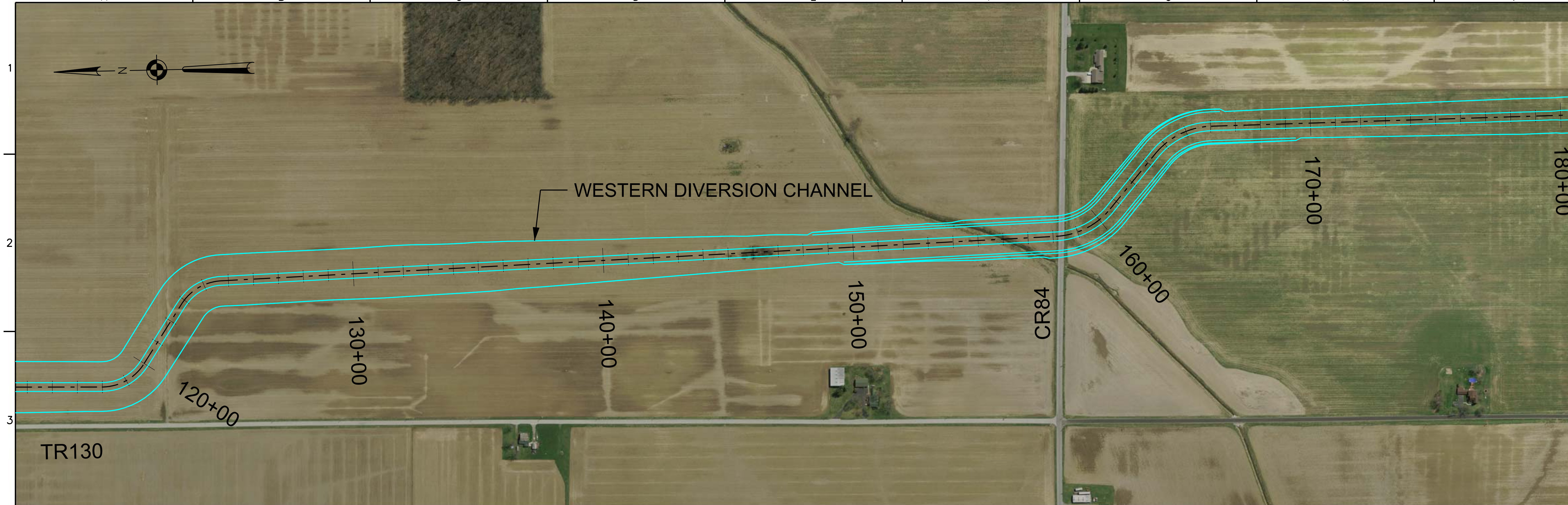
BLANCHARD RIVER WATERSHED STUDY
DRAFT INTERIM FEASIBILITY REPORT

WESTERN DIVERSION CHANNEL
CONCEPTUAL PLAN & PROFILE
STA. 59+00 TO STA. 118+00

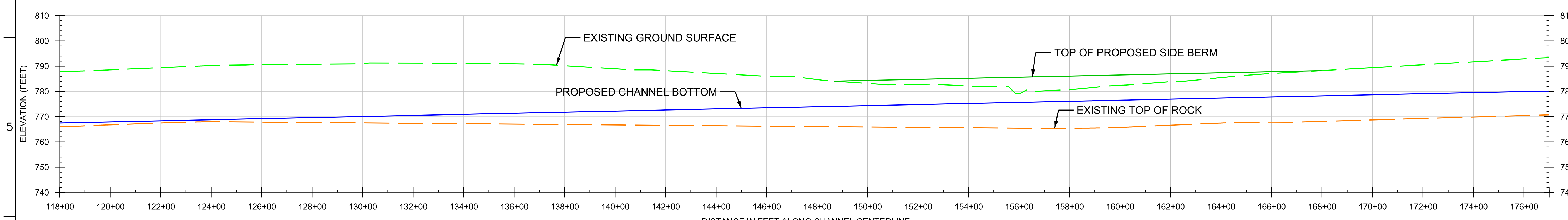
FIGURE 12



PLAN

SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT
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BUFFALO, NEW YORK 14207

Date: DECEMBER 2014
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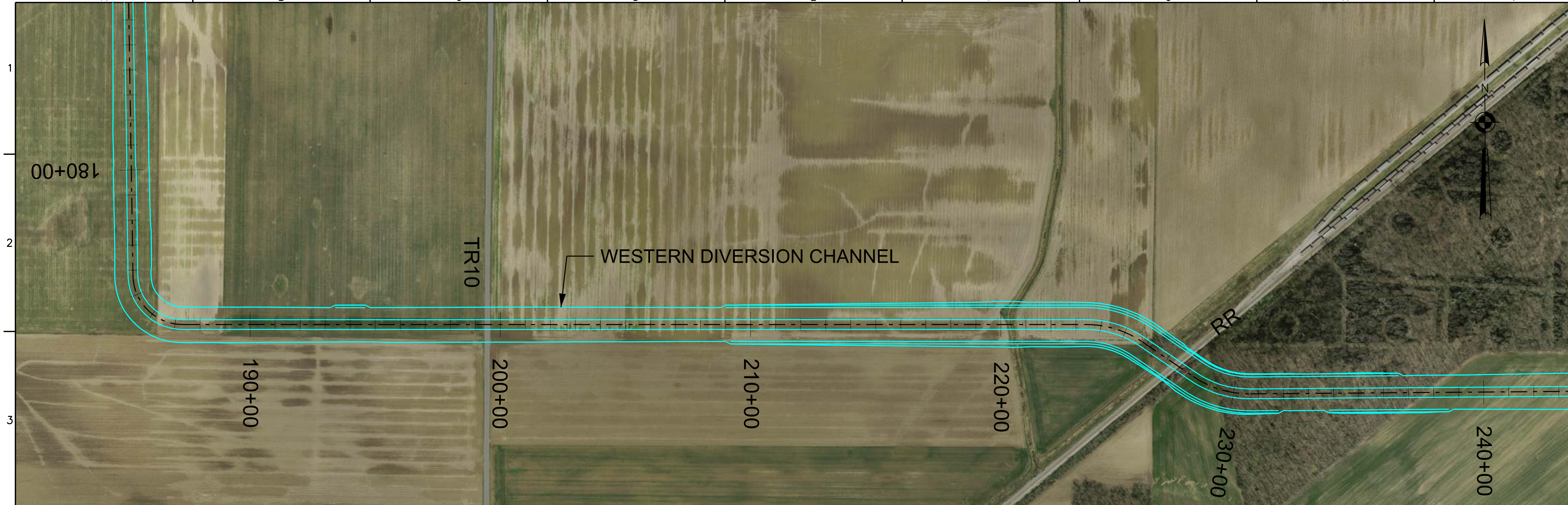
BLANCHARD RIVER WATERSHED STUDY
DRAFT INTERIM FEASIBILITY REPORT

WESTERN DIVERSION CHANNEL
CONCEPTUAL PLAN & PROFILE
STA. 118+00 TO STA. 177+00

FIGURE 13

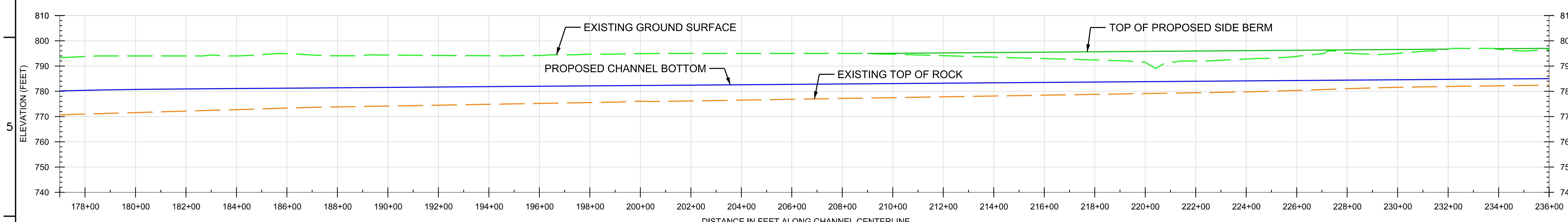


PLAN

200' 100' 0 200'

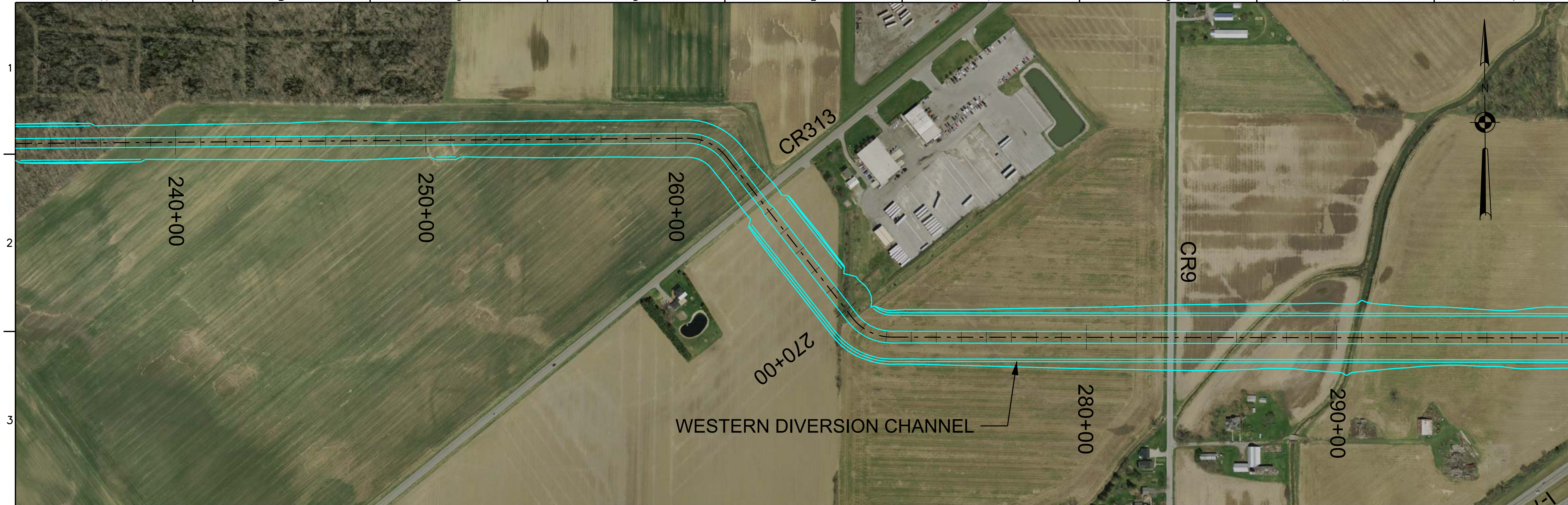
SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 177+00 TO STA. 236+00	FIGURE 14
Date: DECEMBER 2014 — Scale: AS SHOWN		

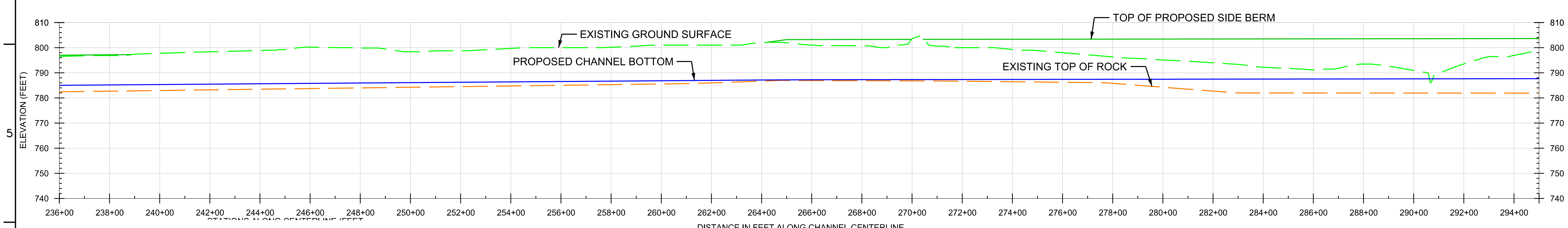


PLAN

200' 100' 0 200'

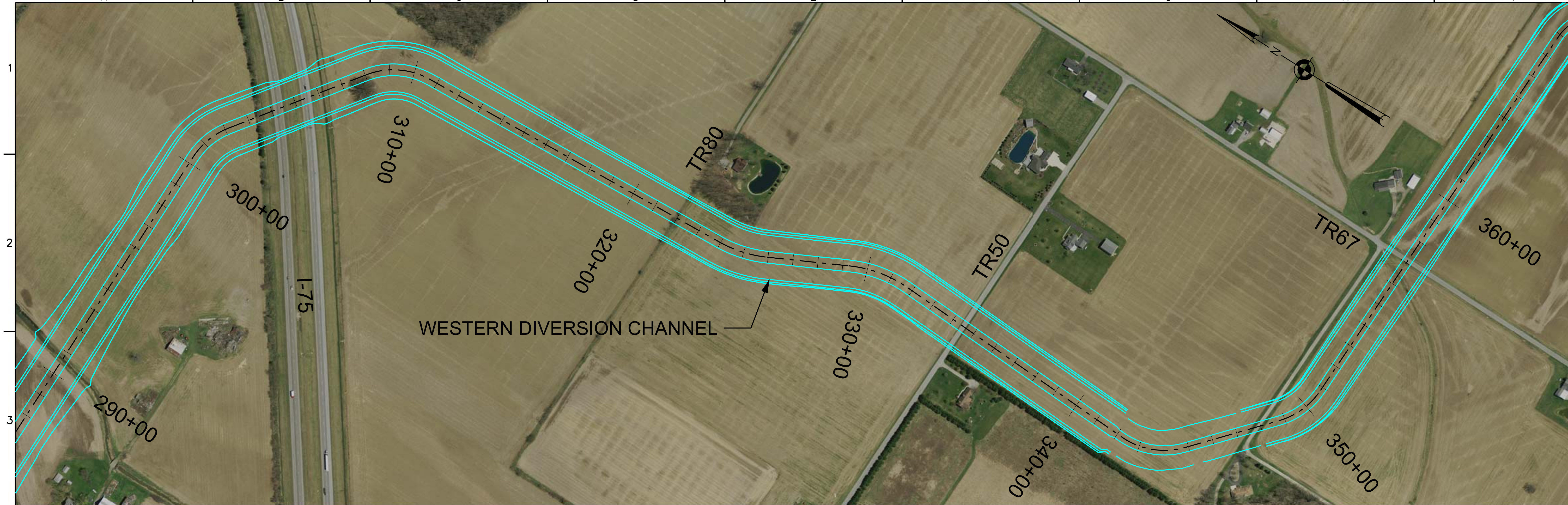
SCALE: 1''= 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207 Date: DECEMBER 2014 Scale: AS SHOWN	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 236+00 TO STA. 295+00	FIGURE 15

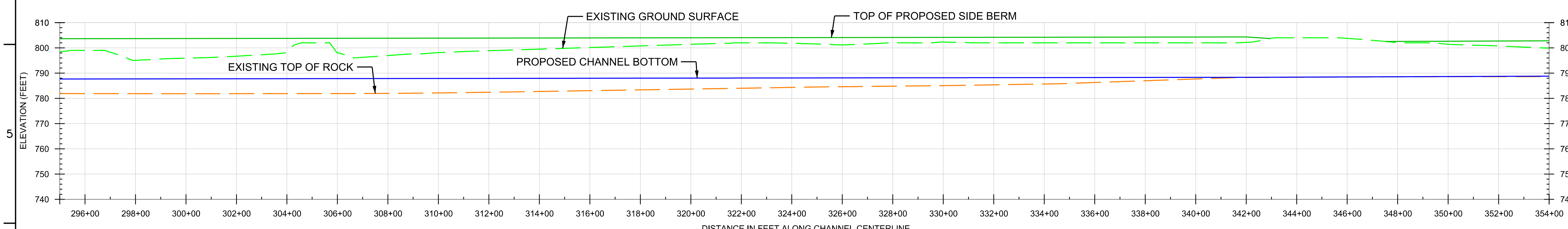


PLAN

200' 100' 0 200'

SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT
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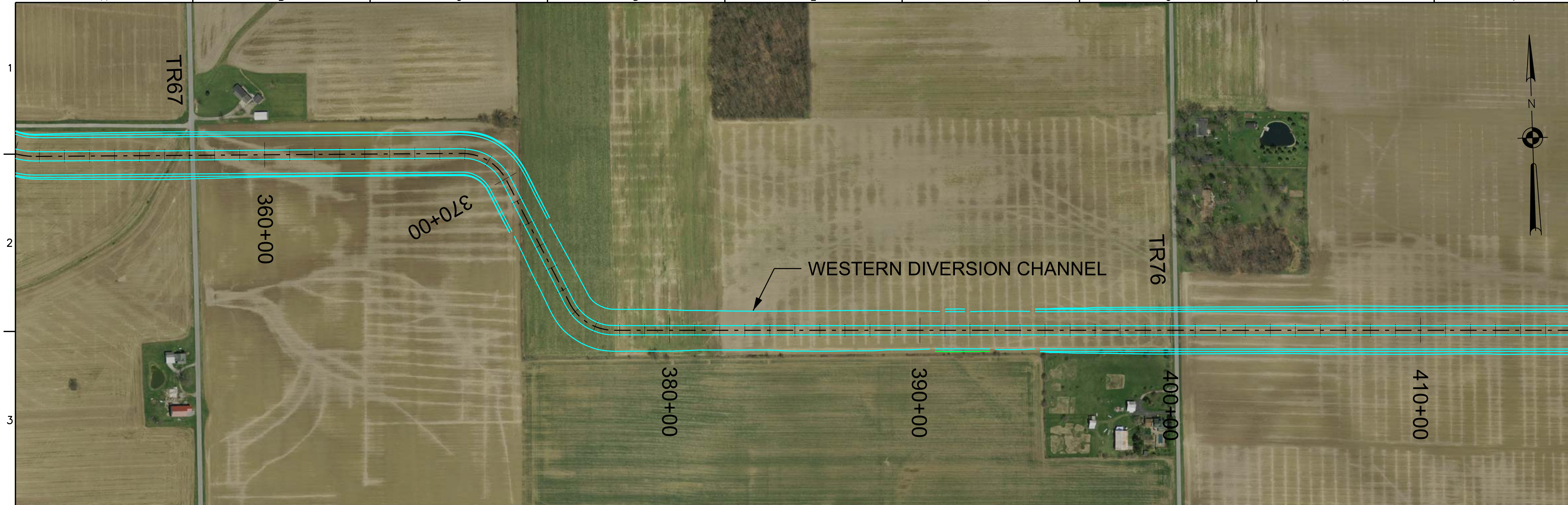
BLANCHARD RIVER WATERSHED STUDY
DRAFT INTERIM FEASIBILITY REPORT

WESTERN DIVERSION CHANNEL
CONCEPTUAL PLAN & PROFILE
STA. 295+00 TO STA. 354+00

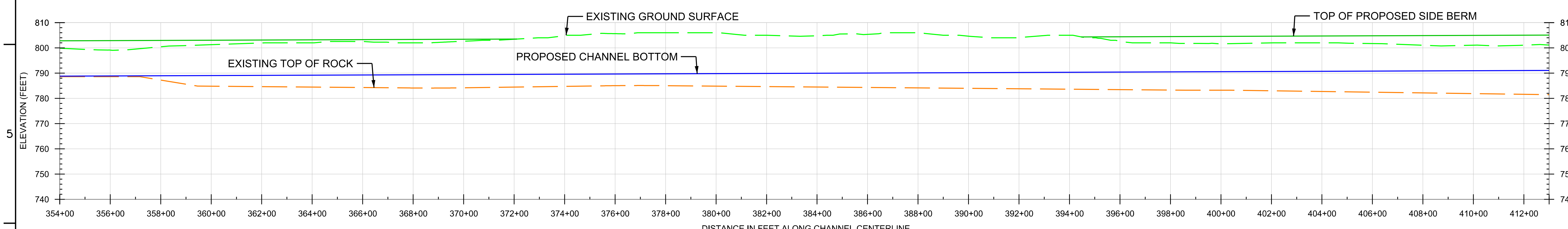
FIGURE 16



PLAN

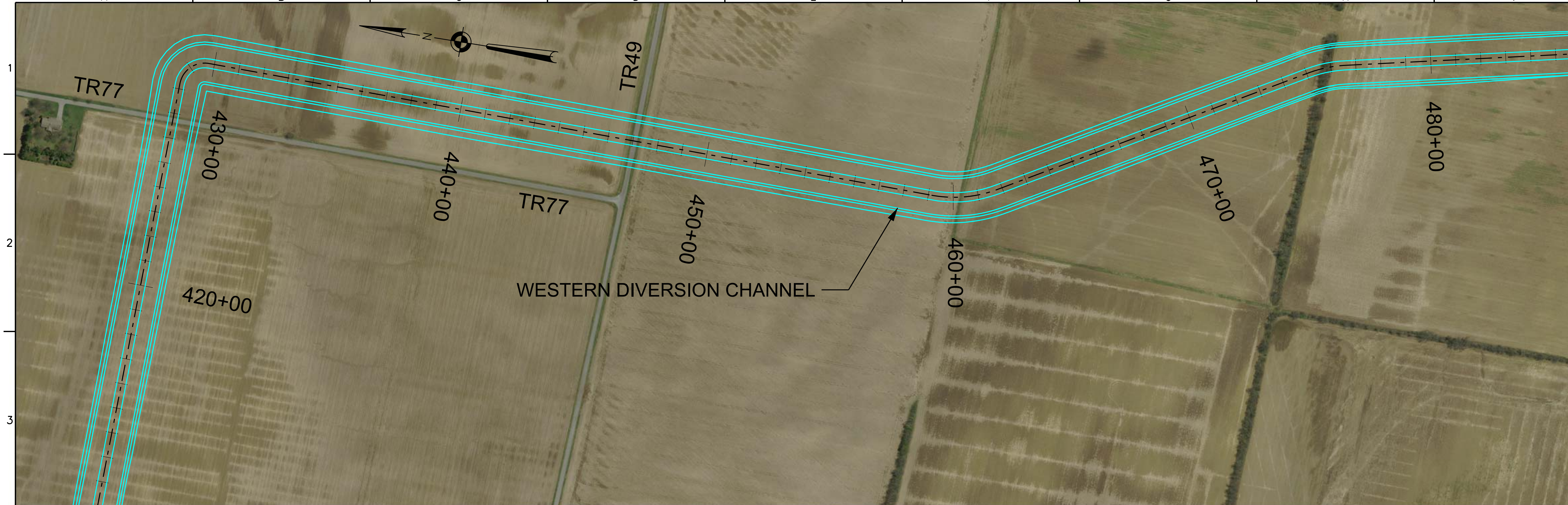
SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207 Date: DECEMBER 2014 Scale: AS SHOWN	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT	WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 354+00 TO STA. 413+00	FIGURE 17

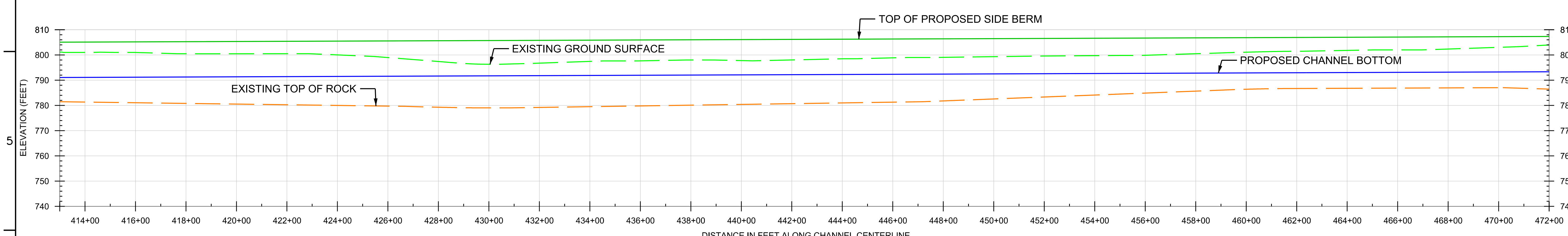


PLAN

200' 100' 0 200'

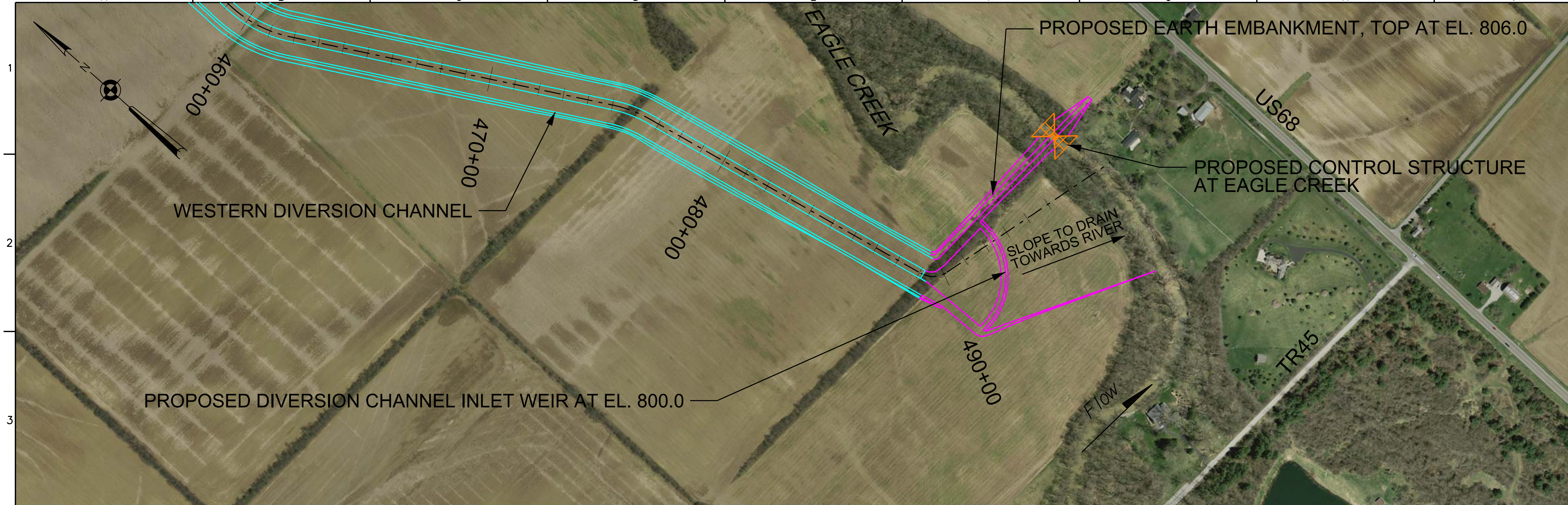
SCALE: 1''= 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207 Date: DECEMBER 2014 Scale: AS SHOWN	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 413+00 TO STA. 472+00	FIGURE 18

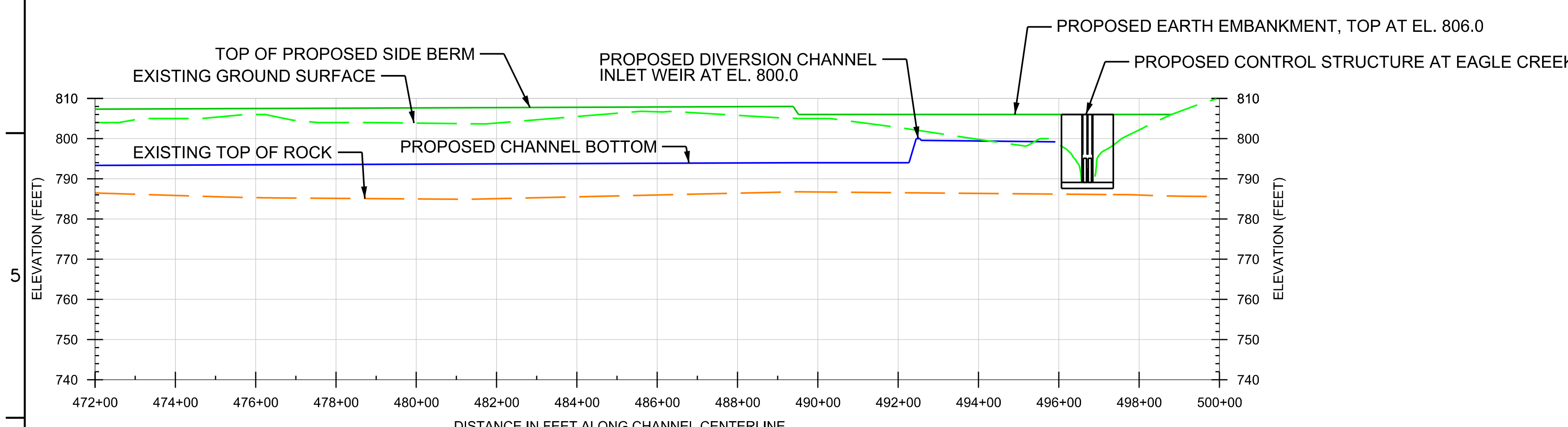


PLAN

200' 100' 0 200'

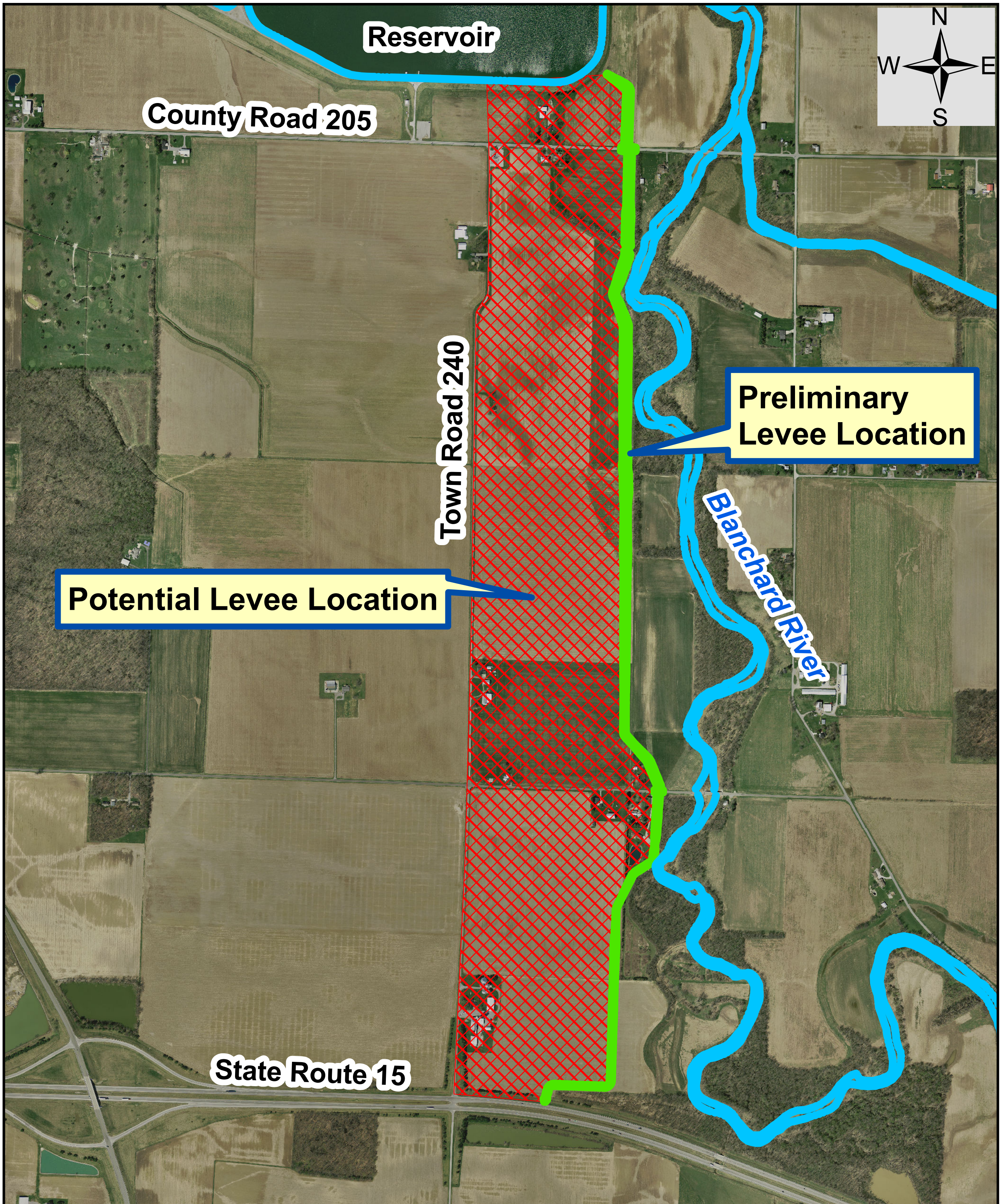
SCALE: 1'' = 400'-0"

NOTE: LOCATION OF WESTERN DIVERSION CHANNEL SHOWN ON PLAN IS PRELIMINARY. ACTUAL LOCATION COULD BE ANYWHERE WITHIN THE CORRIDOR SHOWN ON FIGURE 4.



PROFILE

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NEW YORK 14207 Date: DECEMBER 2014 Scale: AS SHOWN	BLANCHARD RIVER WATERSHED STUDY DRAFT INTERIM FEASIBILITY REPORT WESTERN DIVERSION CHANNEL CONCEPTUAL PLAN & PROFILE STA. 472+00 TO STA. 500+00	FIGURE 19



Feet
0 500 1,000 1,500 2,000

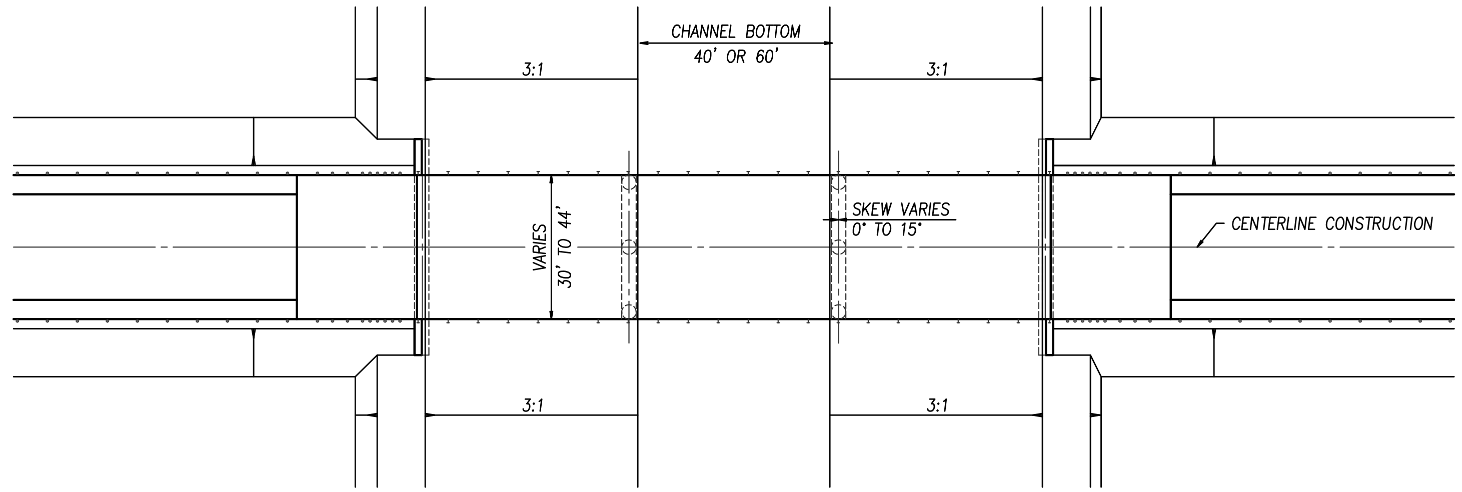
Legend

Preliminary Levee Location

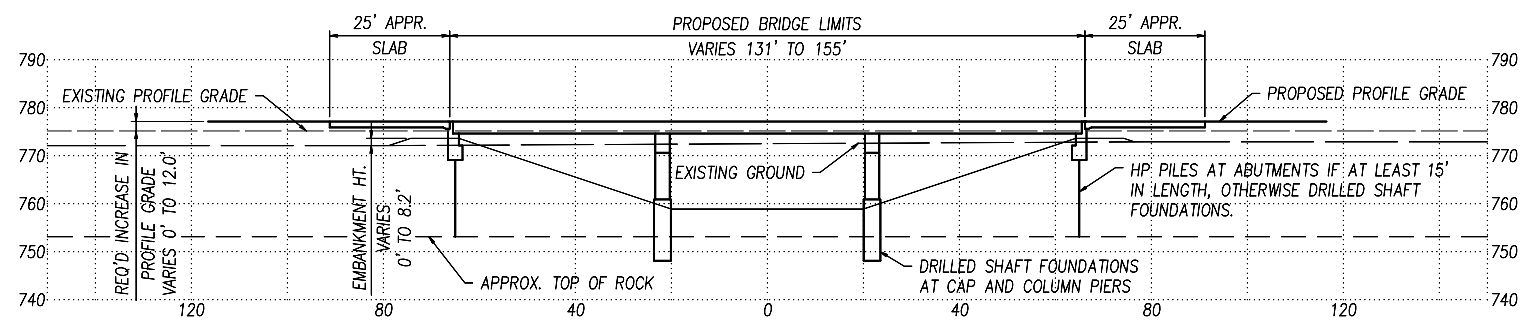
Potential Levee Location

Blanchard River Watershed Study
Draft Interim Feasibility Report

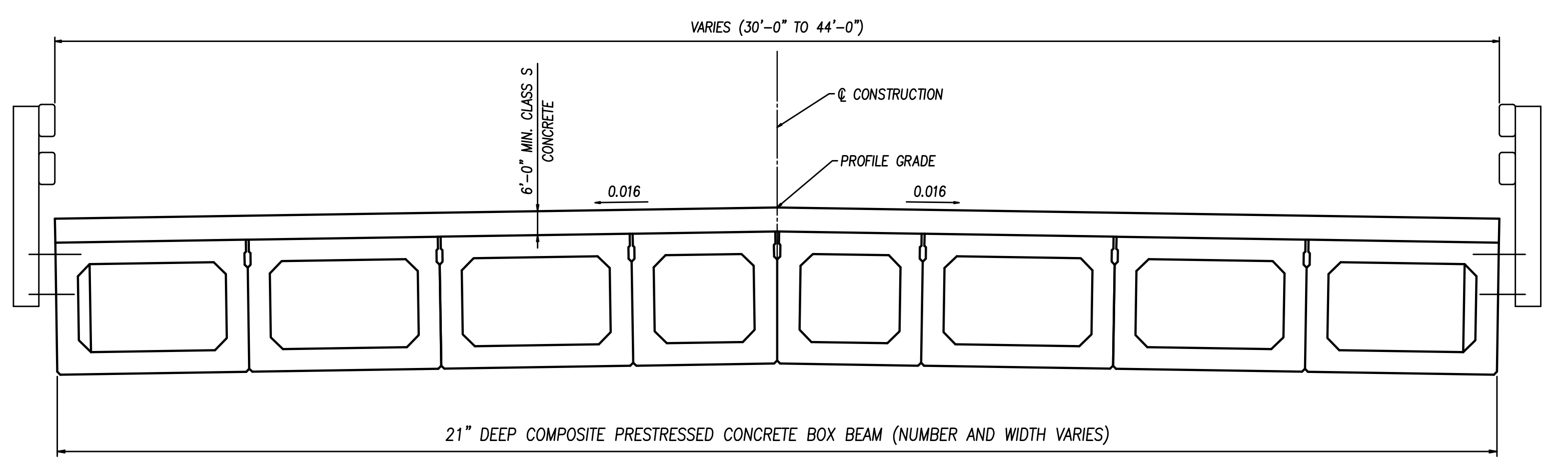
Figure 20: Lye Creek Cutoff Levee
December 2014



GENERAL PLAN



ELEVATION



TYPICAL PROPOSED TRANSVERSE BRIDGE SECTION

US Army Corps of Engineers®
Buffalo District

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
BUFFALO, NEW YORK

URS CORPORATION
1375 EUCLID AVENUE
CLEVELAND, OHIO
AE CONTRACT NUMBER

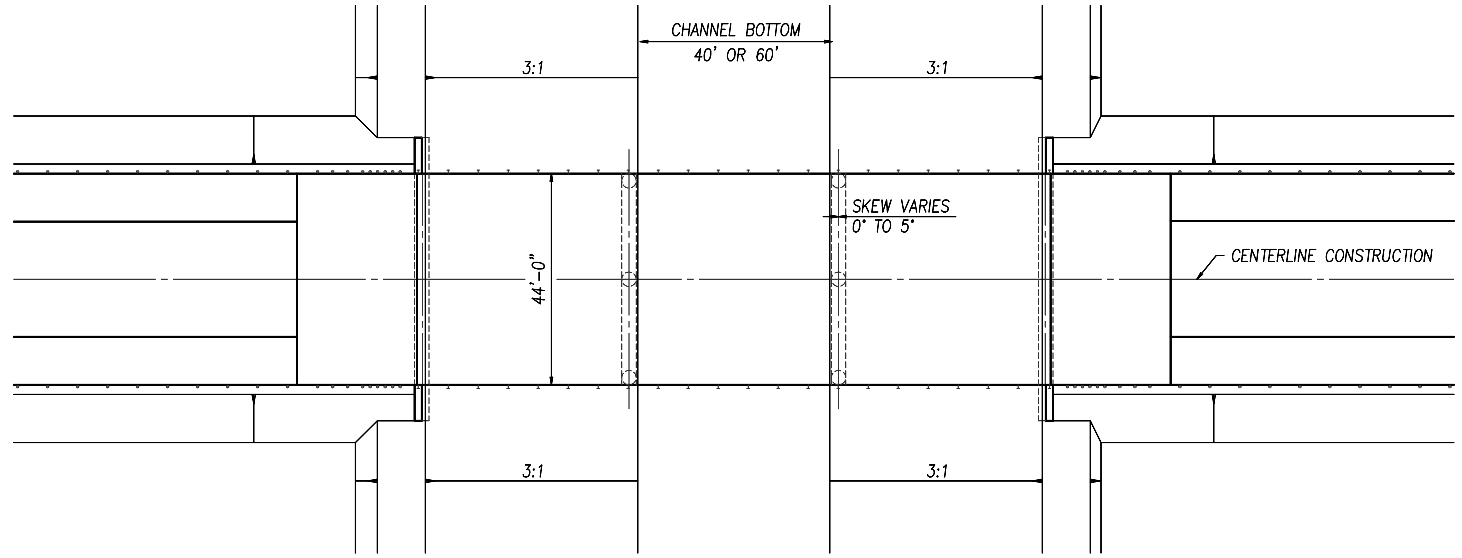
DESIGNED BY: D. CAUBLE
DWN BY: C. SMITH
CKD BY: M. JOHNSON
DATE: JUNE 2012
SOLICITATION NO.:
SUBMITTED BY:
CONTRACT NO.:
PLOT SCALE: AS SHOWN
PLOT DATE:
FILE NUMBER:
SIZE: ANSI D
FILE NAME:

BLANCHARD RIVER WATERSHED
LOCAL FLOOD PROTECTION
FINDLAY, OHIO

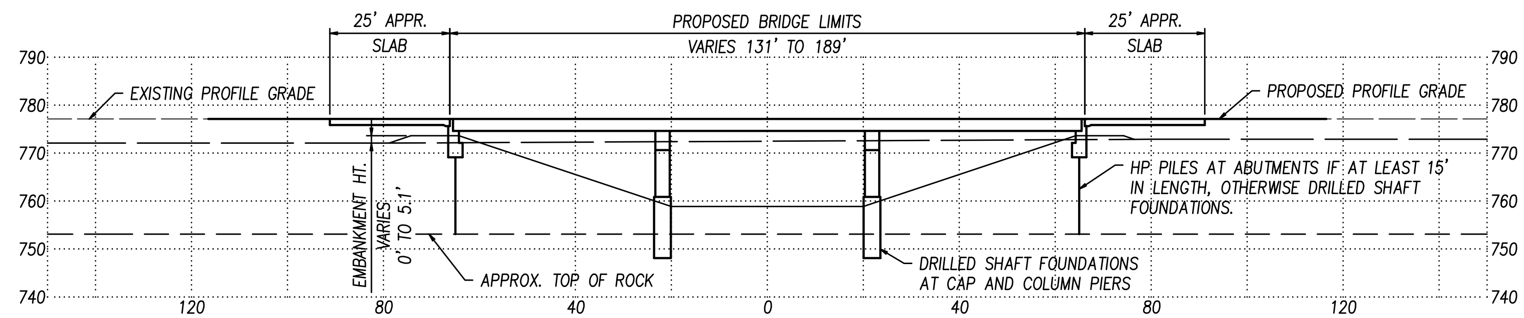
PRELIMINARY BRIDGE DESIGN
LOCAL ROAD STRUCTURES

Sheet ID
FIGURE 21

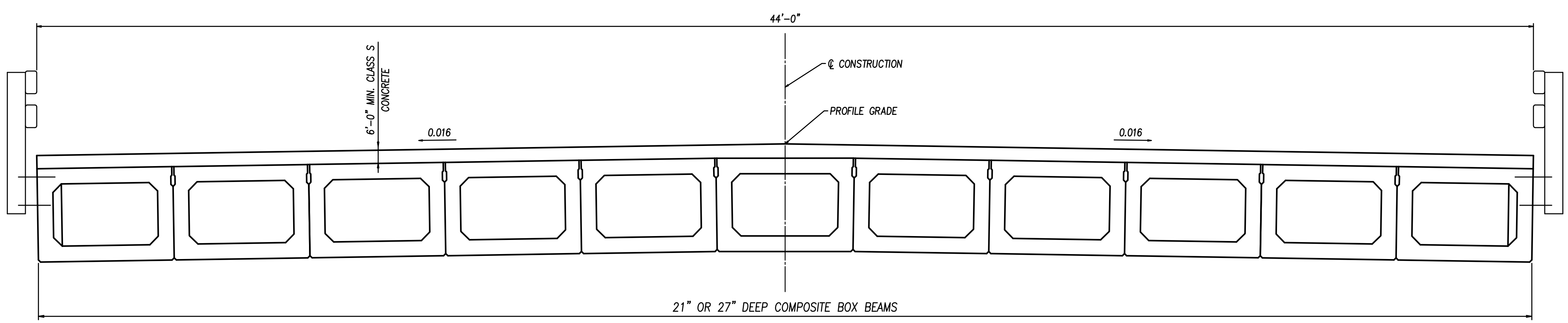
Time: 8:33 A.M. Date: 5/2/2014 Onsy_Moawad Drawing File: K:\13814527 Blanchard AFB\Engineering\Report\Figures\CADD\FIG21-Local Road Details.dwg



GENERAL PLAN



ELEVATION



TYPICAL PROPOSED TRANSVERSE BRIDGE SECTION

US Army Corps of Engineers®
Buffalo District

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

DATE: JUNE 2012
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
DESIGNED BY: D. CAUBLE
DWN BY: C. SMITH
CKD BY: M. JOHNSON
SUBMITTED BY:
PLOT SCALE: AS SHOWN
PLOT DATE:
SIZE: ANSI D
FILE NAME:

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
BUFFALO, NEW YORK

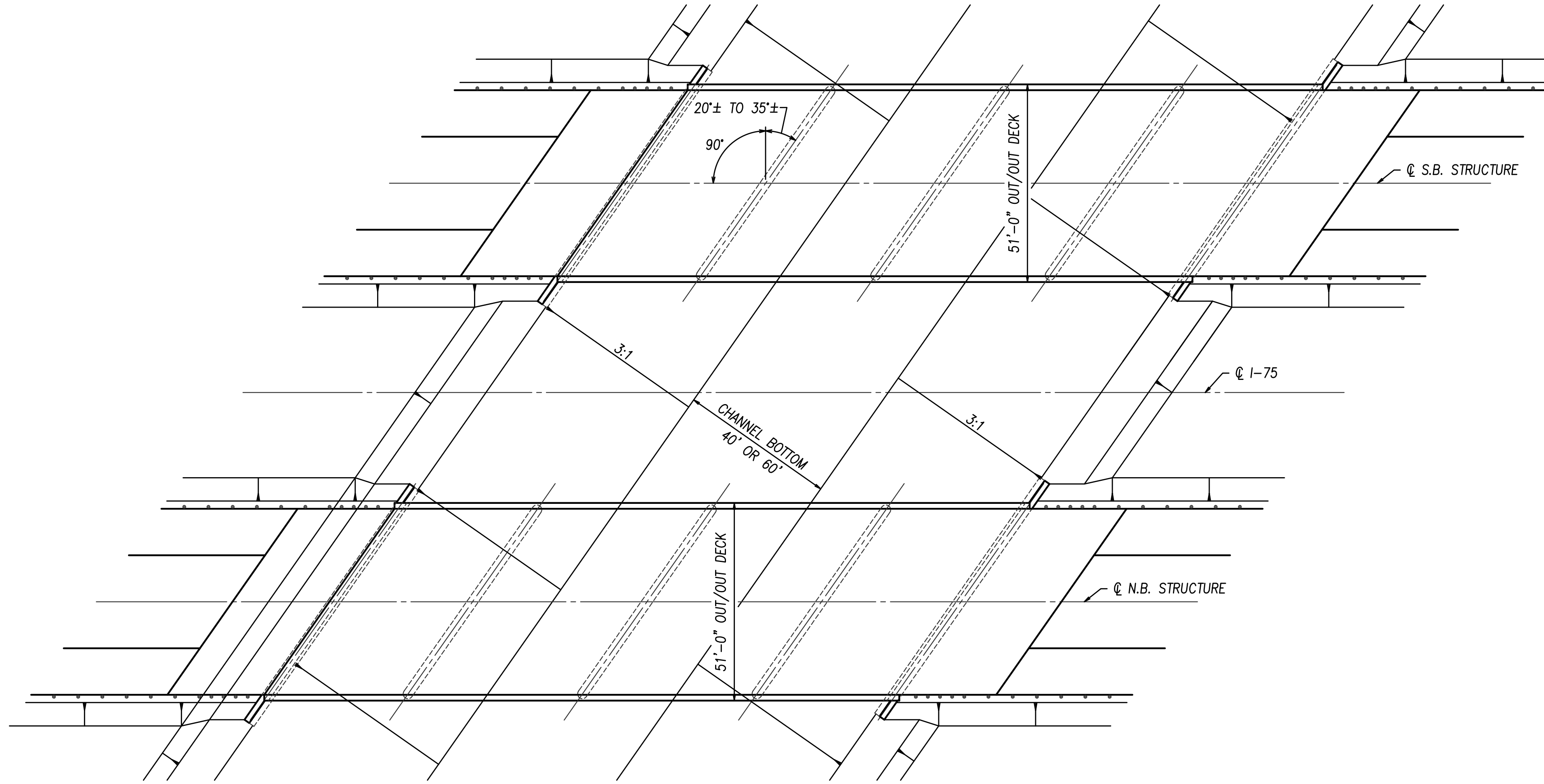
URS CORPORATION
1375 EUCLID AVENUE
CLEVELAND, OHIO
AE CONTRACT NUMBER

BLANCHARD RIVER WATERSHED
LOCAL FLOOD PROTECTION
FINDLAY, OHIO

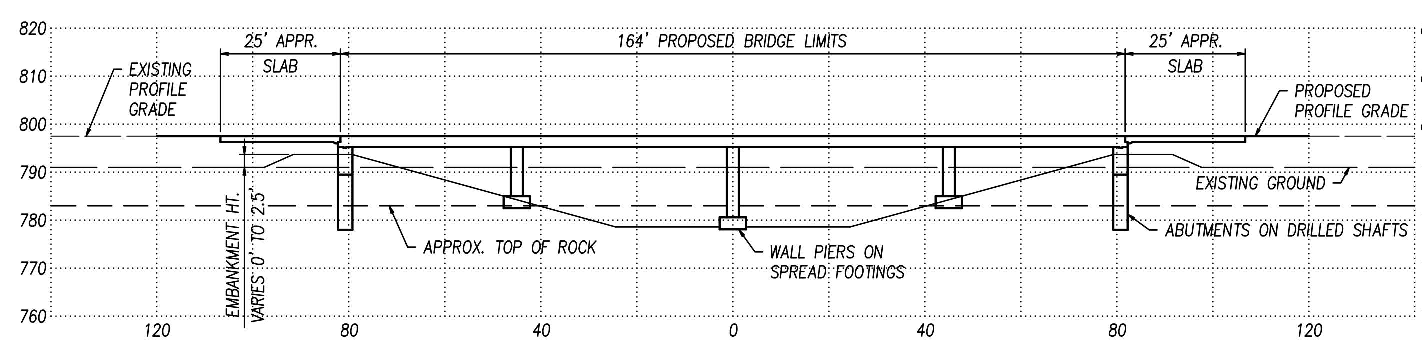
PRELIMINARY BRIDGE DESIGN
STATE ROUTE STRUCTURES

Sheet ID
FIGURE 22

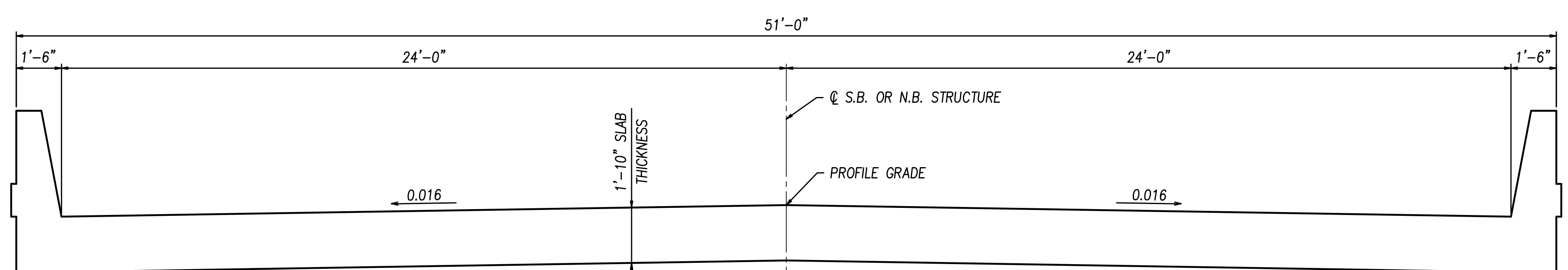
Time: 8:33 A.M. Date: 5/2/2014 Onsy_Moawad Drawing File: K:\13814527 Blanchard AFB\Engineering\Report\Figures\CADD\FIG22-State Route Details.dwg



GENERAL PLAN



ELEVATION



PROPOSED TYPICAL BRIDGE SECTION

US Army Corps of Engineers
Buffalo District

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: D. CAUBLE
DWN BY: C. SMITH
CKD BY: M. JOHNSON
SUBMITTED BY:
DATE: JUNE 2012
SOLICITATION NO.:
CONTRACT NO.:
PLOT SCALE: AS SHOWN
PLOT DATE:
FILE NUMBER:
SIZE: ANSI D
FILE NAME:

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
BUFFALO, NEW YORK

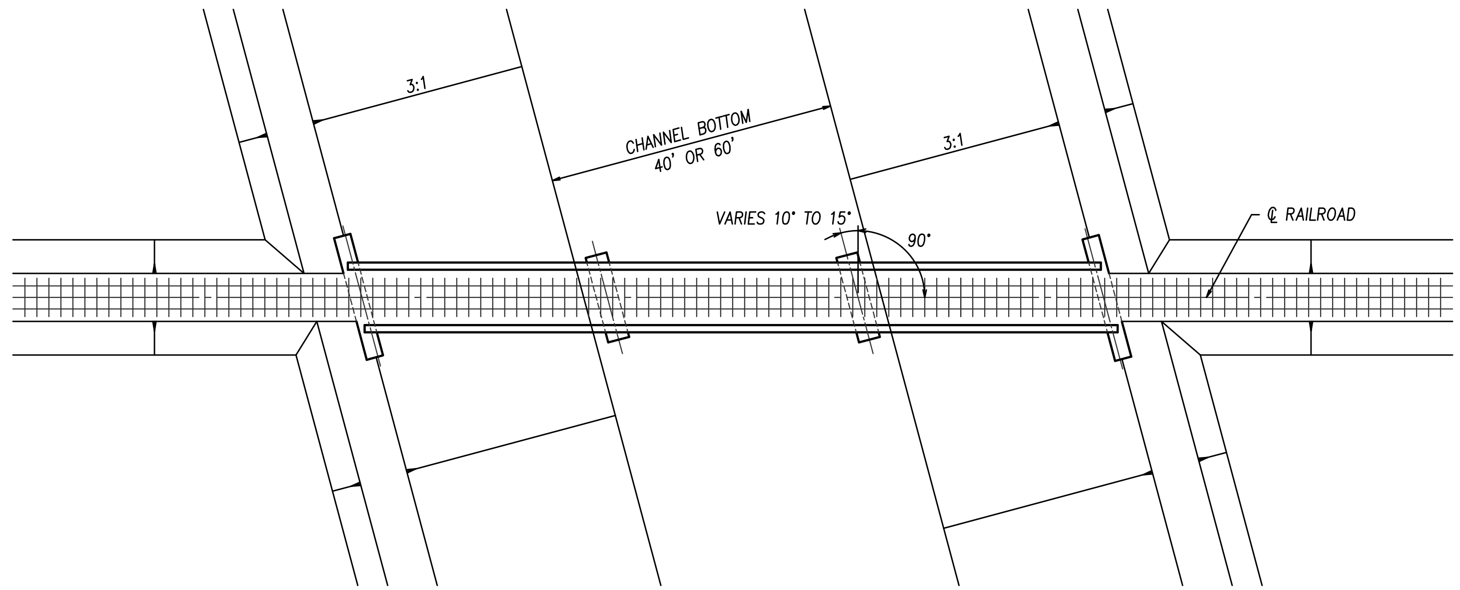
URS CORPORATION
1375 EUCLID AVENUE
CLEVELAND, OHIO
AE CONTRACT NUMBER

BLANCHARD RIVER WATERSHED
LOCAL FLOOD PROTECTION
FINDLAY, OHIO

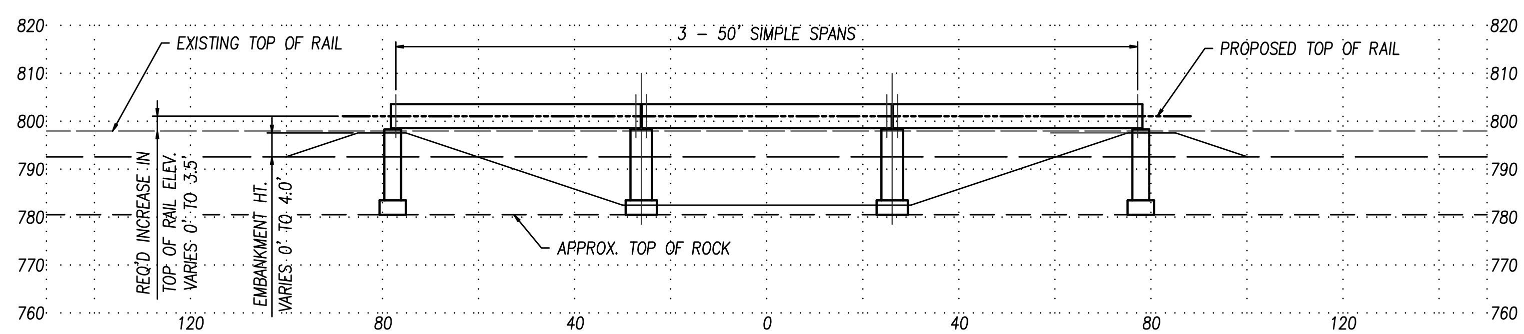
PRELIMINARY BRIDGE DESIGN
INTERSTATE STRUCTURES

Sheet ID
FIGURE 23

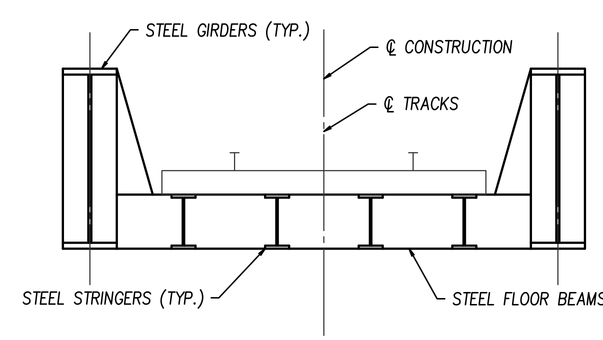
Time: 8:35 A.M. Date: 5/2/2014 Onsy_Moawad Drawing File: K:\13814527 Blanchard AFB\Engineering\Report\Figures\CADD\FIG23—Interstate Details.dwg



GENERAL PLAN



ELEVATION



TYPICAL PROPOSED TRANSVERSE BRIDGE SECTION

US Army Corps of Engineers
Buffalo District

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: D. CAUBLE
DWN BY: C. SMITH
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FILE NUMBER:
SIZE: ANSI D
FILE NAME:

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
BUFFALO, NEW YORK

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1375 EUCLID AVENUE
CLEVELAND, OHIO
AE CONTRACT NUMBER

BLANCHARD RIVER WATERSHED
LOCAL FLOOD PROTECTION
FINDLAY, OHIO

PRELIMINARY BRIDGE DESIGN
RAILROAD STRUCTURES

Sheet ID
FIGURE 24

Time: 8:34 A.M. Date: 5/2/2014 Onsy_Moawad Drawing File: K:\13814527 Blanchard AFB\Engineering\Report\Figures\CADD\FIG24-Railroad Details.dwg